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Excavation for Foundation of Elephant Butte Dam

By E. H. Baldwin*

The largest and most interesting single feature of the Rio Grande Project is the Elephant Butte Dam.† This is being constructed by the United States Reclamation Service across the Rio Grande at a point about twelve miles west of Engle, New Mexico. The dam has been variously called Engle, Rio Grande and Elephant Butte, but the last has been officially declared the correct name and is appropriate, as the dam site is but a short distance below a very conspicuous butte (Fig. 4) on the most prominent portion of which an elephant's head is very clearly depicted.

The flow of the Rio Grande is very erratic; during the period from 1895 to 1913 (from the records kept at San Marcial), the highest flow was in October, 1904, when it reached 33,000 cu.ft. per sec. The greatest run-off is generally in May and June and the least from July to September, during which time the river frequently goes dry. The drainage area above San Marcial is 30,000 sq. mi., from which the mean annual run-off for the past 18 yr. was 1,125,000 acre-ft. while the maximum was 2,420,000 and the minimum 201,000.

To store the flood waters of the Rio Grande and release it gradually as needed, to supplement the low-water flow

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†Previous articles on the Elephant Butte Dam in "Engineering News" are: Preliminary design, Aug. 18, 1910, p. 167; Specifications, Jan. 16, 1913, p. 120; Concreting Plant, Aug. 6, 1914, p. 292.

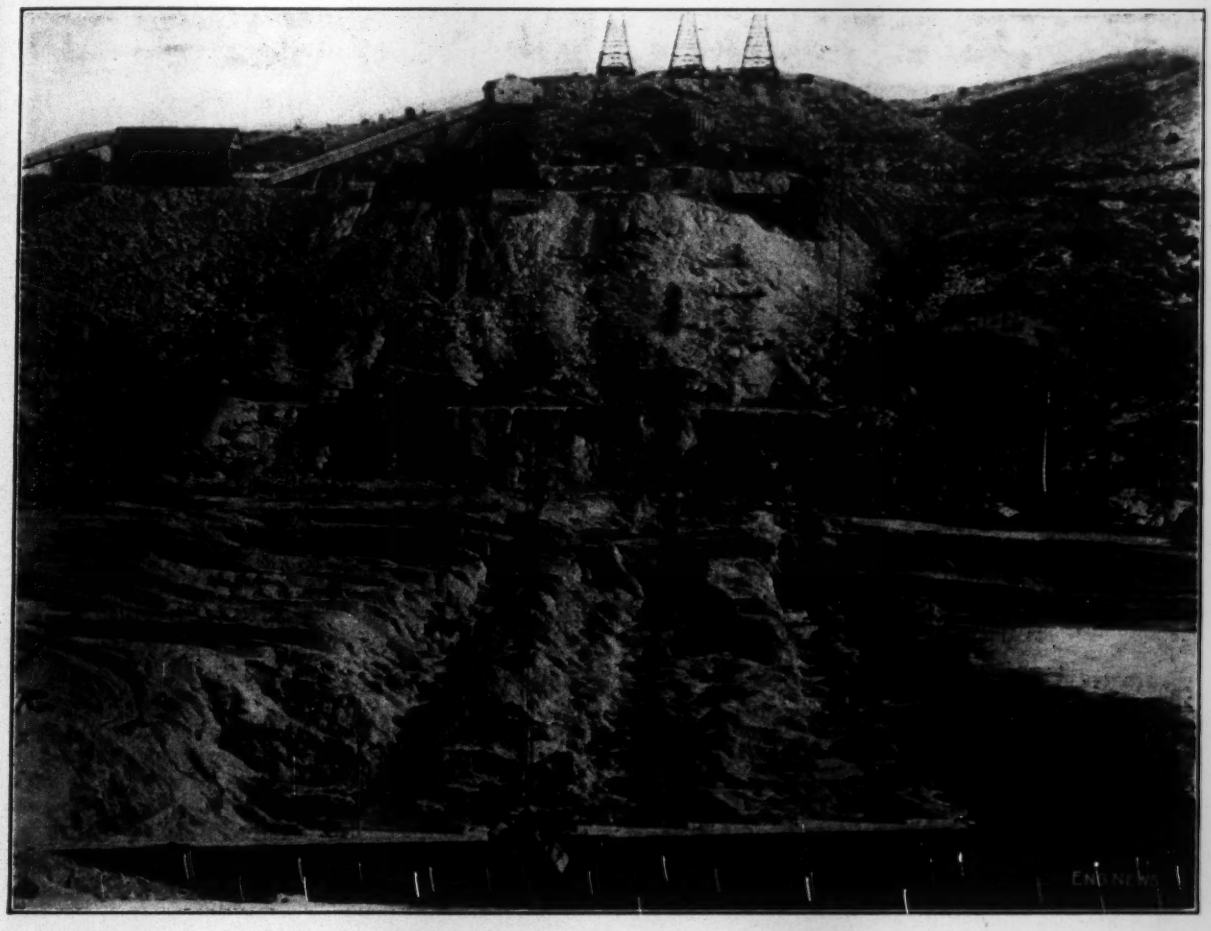

Fig. 1. Foundation Excavation, Elephant Butte Dam, Rio Grande Project, U. S. Reclamation Service

(Looking east. General view of excavation by grab buckets. Note dumping in flume of material unsuitable for concrete aggregate. Hopper on lower railroad for delivering undesirable material to cars, and hoppers on upper railroad for delivering gravel to cars to be stored for subsequent use in concrete.)

and to carry the surplus from year to year, is the purpose of the Elephant Butte Dam, but it will serve another purpose by greatly lessening the floods in the lower valley, that in the years past have proven so destructive. The run-off being so erratic, large storage facilities are necessary to provide a hold-over capacity for the years of minimum flow.

This condition has made feasible and desirable the construction of the dam to a height that will control a reservoir that will be by far the largest in the world for irrigation or domestic purposes. When filled to spillway level,

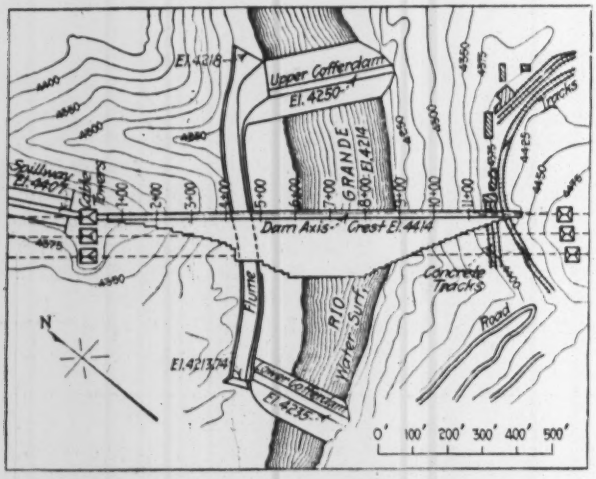

FIG. 2. ELEPHANT BUTTE DAM SITE, SHOWING FLUME, DAM AND CONSTRUCTION LAYOUT

it will contain 2,642,000 acre-ft. of water or 862,000,000,000 gal., an inconceivable quantity, enough to cover the entire State of Delaware 2 ft. deep. At this elevation it will have a surface area of 42,000 acres, will be 40 miles long, with a maximum depth of 193 ft., an average depth of 66 ft. and an average width of 1¾ miles; the shore line will exceed 200 miles in length.

The dam is of the gravity type, straight in plan; it will be 1200 ft. long, maximum height of 305 ft., maximum thickness at base of 225 ft., and will have a roadway 16 ft. wide on top (Fig. 3). It is being constructed of cyclopean concrete with both faces cast against forms, and will contain about 550,000 cu.yd. of masonry. An elaborate system of drains is provided inside the dam, near the upstream face, to carry off any water that may enter. Contraction joints are to be constructed at intervals of about 100 ft. in the portion above river level; below this the structure is monolithic.

PRELIMINARY INVESTIGATIONS

During the season of 1903 some 30 drill holes were put down on lines at some distance upstream from the site finally selected. Many trenches and short tunnels were put in on the abutments of the present site and at two other possible locations upstream from it. This work was scattered over the years from 1903 to 1910 inclusive. In October, 1910, a diamond-drill outfit was started at the dam site to explore the rock foundation; a few months later a second diamond-drill outfit was started and both rigs continued the work until April of the following year; 37 holes were put down to an average depth of 75 ft., penetrating rock to an average depth of 23½ ft. The information resulting from these borings showed the nature of the rock foundation and determined the location of the dam.

NATURE OF SUBSTRATA

The sides of the cañon show thick layers of excellent sandstone considerably broken but having withstood atmospheric action for ages. These layers or strata dip upstream and are separated by comparatively thin layers of shale rock of varying hardness. The original borings with diamond drill indicated somewhat similar foundation conditions, but with much thicker and harder sandstone strata and less shale. Excavation operations closely checked up the preliminary borings, but it was considered advisable to excavate much deeper in the river portion than the borings indicated would be necessary. The deepest excavation was between Sta. 5 + 50 and Sta. 6 + 50, where it was carried to a depth of 100 ft. below bottom of old river bed.

The completed excavation, between cañon walls, is practically all on sandstone which presented a very irregular surface, the general dip being upstream, but broken into humps and hollows, ridges and grooves. The sandstone layers are not only much thicker than was expected from surface indications, but of a very dense, firm texture. The specific gravity of this rock is 2.64 and numerous compressive tests gave an average strength of 10,500 lb. per sq.in.

PLANT

While some preliminary work had been done previous to this time, it was in July, 1910, that actual construction

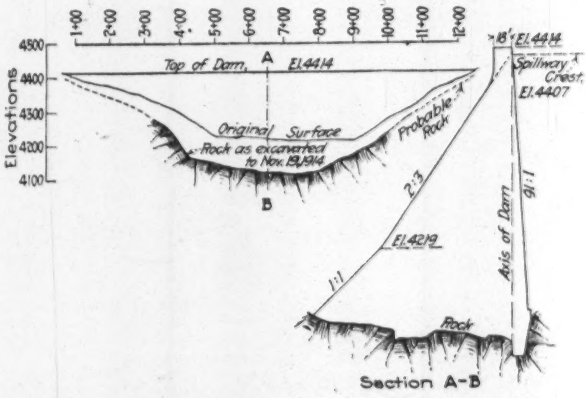

FIG. 3. LONGITUDINAL AND CROSS-SECTION OF THE ELEPHANT BUTTE DAM

work started. A comfortable, convenient and sanitary camp was erected. A branch railroad, standard-gage, was built from the Santa Fé Ry. at Engle to the dam site; this was completed early in 1911. About 2½ miles of terminal-yard tracks, all standard gage, connecting quarries and shops with mixing plant at dam site were constructed. A very convenient and efficient plant was erected during the seasons of 1911-13 inclusive. All portions of the work are connected by telephone, there being 22 miles of lines in use exclusive of toll lines. The water-supply consists of pumping water filtered from the river to two tanks of 300,000 and 75,000 gal. capacity, respectively.

The power plant contains three steam turbo-generators,

each of 500-kw. capacity, the steam being furnished by four boilers, each of 250 hp., fed by mechanical stokers. Current generated at the power house is sent out at 2200 volts and transformed as necessary to 440, 220 and 110 volts. With the exception of the locomotives, electric power is used exclusively on all parts of the work. The mechanical shops, including blacksmith, machine and wood-working shops are so well equipped that it is possible not only to repair any kind of breakdown, but to build almost anything needed. Three cableways, each of 15-ton capacity, span the dam site. They are about 1400 ft. long and 60 ft. apart, the upstream cable being 8 ft. downstream from the axis of the dam. The cableway engines are of 300 hp., with hoisting speed of 200 ft. per min., and running speed of 800 ft. per min. The distance from cables to deepest part of excavation was about 350 ft.

FIG. 4. GENERAL VIEW OF DAM SITE, LOOKING UPSTREAM
(Elephant Butte in right center. Note flume under construction, river in its original location. Horizontal line showing proposed top of dam.)

EXCAVATION METHODS

The flow of the river during construction is being handled by a flume having a capacity of 20,000 cu.ft. per sec. with 2-ft. freeboard and 30,000 cu.ft. per sec. if level full. This is 1200 ft. long, on the west side of the cañon, and its construction presented many difficulties. Reference to Fig. 2 will show the general conditions before construction commenced.

The flume will be considered in two parts, one portion outside the main dam structure, the other being a portion of the dam. Excavation for the flume was begun in February, 1911, and the portion outside of the dam was finished in December of the same year. The amount excavated was about 75,000 cu.yd., of which 50,000 cu.yd. was solid rock. The maximum depth of excavation was 61 ft. Drilling was done by hand. Two 8-hr. shifts were used after July 24. The material was at first transported in narrow-gage cars drawn by mules, but in July this was changed to standard-gage cars handled by locomotives. About 55% of the material was wasted and the balance used in building coffer-dams. Concreting for this portion of the flume was commenced Nov. 20, 1911, and continued without intermission until its completion Feb. 26, 1912. The west side and floor of flume was wholly of concrete, but the east side was concrete only at intake and outlet, the intervening part, except where it crossed the dam, being of wood. Its construction required 5500 cu. yd. of concrete and 80,000 M ft. lumber.

Excavation for the dam section of the flume was in progress near the close of the year 1911 with one derrick; a second derrick was soon added. The material was handled with skips, derricks, cars and locomotives, the greater part of it being used in construction of coffer-dams. On account of the deep cutting, steep slopes and loose rock, the work was extremely dangerous. Slides from the side slopes were of frequent occurrence. Concreting was commenced July 15, 1912, was completed Nov. 1, and the river diverted through it Nov. 6.

Immediately after the river was diverted, excavation with grab buckets of 3 cu.yd. capacity (Fig. 5), operated on cableways, was commenced. At first the material—sand and gravel—was picked up directly under the cableways, though it soon became necessary to tag the buckets to cover more ground. This was done by hand for a time, two or three men pulling on a detachable tag line, swinging the bucket back and forth until the desired amplitude was reached, when the bucket was dropped for its load. This took so much time that an improvement was soon made; several two-drum electric hoists were placed on each coffer-dam and the tagging was done by

power; this was not only much quicker, but enabled a much larger area to be covered.

Extended prospecting for sand for masonry work disclosed the fact that the only suitable sand within reasonable distance was located in the immediate vicinity of the dam site. This condition necessitated the excavation and storing of sufficient sand to build the entire dam, and as this area would be flooded long before the completion of the dam, it was necessary to procure it in advance, and this in a great measure determined the procedure to be followed.

When the sand and gravel in the dam site proper had been removed to a certain depth, it was considered advisable to pull in, remove and store a sufficient quantity of that lying adjacent to it, both up and down stream. Simple drag scrapers without top or bottom and holding about one cubic yard were constructed in the shop. They

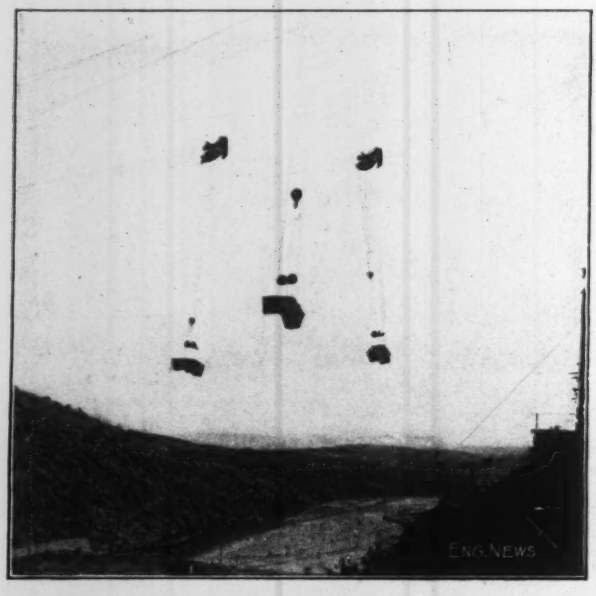

FIG. 5. THREE 3-YD. GRAB BUCKETS DESCENDING FOR LOAD OF GRAVEL, ELEPHANT BUTTE DAM

were worked in pairs by two-drum electric hoists located opposite each other outside the proposed lines of excavation, the drum on one hoist pulling the loaded scraper forward while the back line was reeling off from a drum of the other. The operators soon became quite skillful in the operation of the scrapers. To start a new trench or to avoid cutting too deep, by tightening their lines, then quickly pulling in, the scraper would be thrown and placed where wanted. The scrapers were drawn toward and under the two outer cables while the buckets on those cables were digging elsewhere. The hoists were frequently moved back and forth, parallel with the axis of the dam, by their own power. At times four hoists and scrapers were engaged in this operation while two additional hoists were used for tagging purposes. Some of the near-by material, particularly in corners, was dragged to the cables by teams and fresnos. Fig. 1 gives a good idea of the operation of grab buckets and drag scrapers. Only one drag engine can be seen, the others being out of range of the camera, but the numerous trenches transverse to the axis of the dam were all made by these scrapers.

Whenever material was encountered that was not suitable for concrete aggregate, it was either dumped into the flume to be carried away by the river or into a receiving hopper on the left bank, which guided it into 6-cu.yd. dump cars, handled by a locomotive and dumped on the coffer-dam. All material suitable for concrete was taken by grab buckets to the upper railroad and dumped into storage hoppers, one of which was located under each cableway and at such an elevation that by suitable chutes and gates the material was quickly passed from hopper to cars in which it was carried to storage piles convenient for rehandling. The storage hoppers were of such capacity that the grab buckets could dump independently of the trains.

About the middle of March the bed of sand and gravel overlying the foundation was first penetrated, exposing shale and sandstone. The three grab buckets continued operating until Apr. 12, on which date they were removed and skips substituted temporarily. The skips were loaded by hand, placed under the cableways by derricks and carried to lower railroad for final disposal on coffer-dams. In August grab buckets were placed on outside cableways and the excavation of sand and gravel outside the excavation lines was resumed; this was continued until Nov. 1, when sufficient sand had been obtained.

The grab buckets handled loose material, such as sand and gravel, very efficiently; even when the material was wet, full loads were obtained except occasionally when the jaws were held open by a rock. When this happened it was necessary to dump and reload. No partial loads were allowed, the loading time was so small in comparison with the traveling time that full loads were insisted on. A very small force is required to operate these buckets. When grabbing directly beneath the cable, a signal man for each cable can handle the excavation end. When tagging was being done, two additional men were necessary at each bucket to handle the tag lines. The helpers would stand ready as bucket descended, grab the short line hanging from bucket and quickly attach it to end of cable from tagging engine. These men were selected for agility and trained to work efficiently. The hoist started quickly, the drum being lagged to give better speed, the bucket would be hauled over the pile, held taut while it descended and loaded, then the tag line slackened until the bucket came beneath the cable, when it was quickly cast off and the bucket hoisted.

When excavation with grab buckets started, it was at once seen that to obtain the greatest efficiency it would be necessary to keep the cables going and to eliminate every false move on the part of those engaged in their operation. With this idea in mind a man from the engineering force was stationed with stop watch where he could observe all operations. This was continued for several days, the time of each operation on each cable being taken on each shift. The results were plotted, the curves, five for each round trip, indicated the operations where improvement could be made; this was consistently followed up and a very efficient organization soon obtained. Rivalry between the different crews of a shift and between different shifts was fostered. Conditions were made as nearly uniform as possible. Accurate records were kept of the number of trips made by each cable and of the yardage handled by each bucket. These were tabulated with typewriter and posted daily where all interested could see them. Progress curves for each

shift were plotted daily in the office and summed up at the end of each month. These curves showed at a glance how the different shifts were running.

The best day's performance of grab buckets for the three shifts with all cables in operation was 1817 cu.yd. The best run for the three buckets, one shift, was 722 cu. yd. The best run for one bucket, one shift, was 288 cu. yd. The total excavation by grab buckets was 204,000 cu. yd., of which amount 160,000 cu.yd. was stored for use in masonry. The total excavation to date is about 475,000 cu.yd., of which amount about 200,000 cu.yd. is solid rock.

Realizing the fact that during the several months the two outside cableways would be engaged in removing gravel the middle cable would be of little service for excavation and wishing to push the work to the utmost, utilizing the plant to the greatest extent, it was decided to prepare for masonry an area of suitable size adjacent to and east of the flume block and to use the middle cable in transporting rock and concrete to it. Fig. 7 shows this area after the top had been removed by grab buckets. The remaining material was removed in skips by derrick.

Owing to the peculiar rock formation unusual care had to be exercised in preparing the foundation. The final trimming preparatory to concreting was carried on without explosives. The excavation of the cutoff trench, which lies in front of the axis, required even greater care and was much harder to excavate on account of cramped working quarters and the constant danger from falling rock. The cutoff trench averages 10 ft. wide and 15 ft. deep with reference to the adjoining excavation, but on the upstream side a large portion of it is from 50 to 100 ft. deep. The downstream side was cut by a channeling machine, the opposite side was drilled with holes very close together and the material between loosened with very light charges of powder.

Perhaps the most remarkable feature of the excavation was the small amount of water encountered. A pumping equipment suitable for work of this magnitude was on hand, but it was found that two 4-in. centrifugal pumps were sufficient. Even when excavation was practically completed, covering an area of perhaps eight acres, a portion of it being 100 ft. below the bottom of the river, which was carrying some 8000 sec.-ft., these pumps were sufficient. At the west abutment, when the excavation was some 60 ft. lower than the bottom of the flume and directly beneath it, with the river flowing 4000 sec.-ft., there was not even a trace of dampness.

The area next to the flume block was ready for masonry June 3, 1913, and it was started on that day, using the middle cableway for transporting concrete and plum rock. From that date excavation and concreting proceeded together, using one cable on concrete and two on excavation. Fig. 6, from a photograph taken Jan. 1, 1914, shows the block under construction, an adjacent portion ready for masonry and the preparation of an additional area in the foreground. By Oct. 1, 1914, the entire foundation from Sta. 3 + 50 to Sta. 10 + 00 was ready for masonry. Until March, 1914, only one cable was used on concrete but since that date two cables and sometimes three have been used.

FIG. 6. BEDROCK IN FLUME SECTION. FLUME IN BACKGROUND

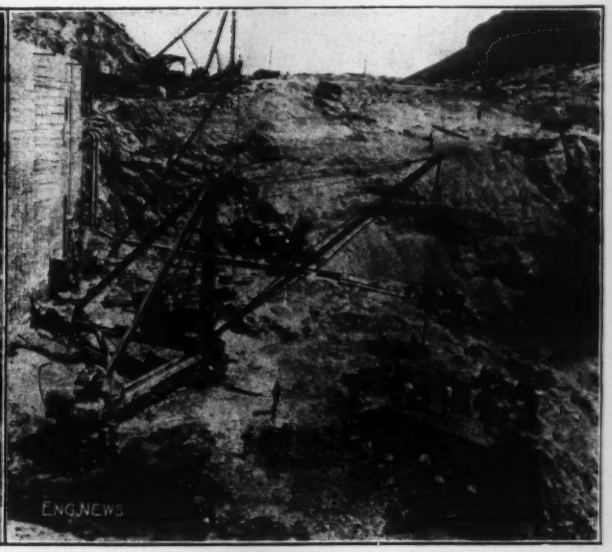

FIG. 7. PREPARING AREA NEXT TO FLUME BLOCK FOR MASONRY

EXCAVATION WORK IN FOUNDATION OF ELEPHANT BUTTE DAM

The excavation at abutments was carried on intermittently and is still in progress. They were seldom worked on at the same time. The general procedure was to excavate to a certain height on one abutment, preparing it for masonry, then, while the masonry crews were placing masonry, the excavating crews would be excavating at the opposite abutment. This method was rendered necessary by the peculiarity of the foundation and the height of the abutments. Unless this was done, frequent cloudbursts would cause the excavation to fill with material from above, and even the better grade of sandstone would crack when exposed for some time to weather.

Practically all operations are worked three shifts. Excellent lighting facilities enable as good progress to be made at night as during the day. In this climate winter

is as favorable for construction operations as summer, consequently, the work is going on all the time except Sundays, on which days only repair work is done, but with so much machinery this is considerable. In January, 1914, 81 shifts were worked. For some months the force employed has fluctuated between 1100 and 1350 men, the latter being the number at present, the greater part of whom are in the quarries and on masonry work.

Standardizing Engineering Positions and Salaries in New York City

The City of New York expends annually about $200,000,000. It employs in its various departments the largest number of engineers, without doubt, of any city in the United States, and probably of any city in the world. The fixing of wages, salaries, grades, duties and promotion of the host of employees in the service of New York City has hitherto rested largely on past precedents, with more or less of political and personal influence in various departments. It is generally conceded by those best informed that many of the city employees are overpaid for their work, while others receive compensation inadequate for the responsibilities they carry and the amount of work they perform.

There has recently been established, under direction of the Board of Estimate and Apportionment, a Bureau of Standards, which has undertaken the large task of classifying and standardizing the work of all the city's employees. On Nov. 16 last a plan for such standardization was laid before the Board by the Director of the Bureau, George L. Tirrell; and while this classification has not yet been formally adopted by the Board, it has already been made use of in making up the budget estimate for the year 1915.

Under the plan adopted, the work of each individual in the city's employ was classified and appraised, with the result that an embargo was placed on any further inflation of the city's salary roll. Further, the Tax Budget Committee of the Board adopted the general policy that no increase in total salaries paid by the city would be considered. If, however, the head of a department desired to readjust the salaries paid to those under him so as to more justly and fairly reward the workers, he was able to do so, with the coöperation of the Bureau of Standards.

It is recognized, however, that any wholesale readjustment of salaries at the present time would result in wide spread dissatisfaction among the city's employees; and it is proposed, therefore, to make the readjustment a gradual one, to be put into effect as resignations and vacancies occur, so that final readjustment and standardization of salaries and duties will only be accomplished at the end of seven or eight years.

In fixing the rates of salary to be paid for certain service the Bureau has been governed by the following general considerations:

(1) The compensation paid for similar service elsewhere; (2) the type of employee wanted from the standpoint of education and experience; (3) the satisfaction or dissatisfaction of employees and department heads with the present range of salaries, advancements, and the conditions surrounding work; (4) the civil service experience in examining candidates for the position in question; (5) the fact that owing to conditions apparently inherent in city employment under civil service restrictions it is necessary to pay a compensation 10% to 20% higher than that which is paid in private employment; (6) the approved modern theory that the city should be a model employer.

The general classification adopted is, in very brief outline, as follows: All city employees have been divided into general classes called "Services." Each Service has been subdivided into "Groups." The work done in each group has been subdivided into "Grades," based upon the importance, difficulty, responsibility and value. There are seventeen different Services. Examples are: Executive, judicial, managerial, professional, subprofessional, laboratory, police, street cleaning, unskilled labor. Some of the groups under the "Professional" Service are architect, accountant, engineer, lawyer, physician. Under "Subprofessional" are the Groups, draftsman, laboratory assistant, law clerk, pupil nurse, transitman.

In the report of Nov. 17, the grading adopted for the engineer Group is given in detail. The six Grades proposed are as follows: Grade 1, engineering assistant, salary $900 to $$1140; Grade 2, junior engineer, salary $1260 to $2040; Grade 3, assistant engineer, salary $2220 to $3120; Grade 4, engineer, salary $3360 to $4500; Grade 5, senior engineer, salary $4800 to $5700; grade 6, chief engineer and consulting engineer, salary from $6000 upwards.

Persons holding positions in any of these grades "must have had such training in civil, mechanical, electrical, sanitary or other engineering branches as is evident by a professional degree granted on the completion of a standard course of instruction in an engineering school of recognized standing or by other proof of training in engineering recognized by the Municipal Civil Service Commission as equivalent, and such additional qualifications as may be required by the Municipal Civil Service Commission."

Within each grade, several salary rates are established, and it is the intention that employees shall be promoted from one rate to another within the grade according to their competency. The conditions proposed for promotion as as follows:

Completion of at least one year of satisfactory service at the lower rate as indicated by the efficiency record of the Civil Service Commission, supplemented by investigation by the Bureau of Standards. The standard of satisfactory service established by the Bureau of Standards shall be progressively higher in each succeeding grade. (2) In the higher grades, advancement shall be made only after appraisal by the Bureau of Standards, indicating that the compensation requested does not exceed the value of the work to be performed.

The qualifications of appointment to grade 1 are, as stated above, posession of an engineering degree, but not necessarily any experience in engineering practice. Appointment to grade 2 can be made from those who have had not less than one year of experience in grade 1 or else in grade 2 of the transitman or draftsman group of the subprofessional Service. Qualifications for service in grade 3, assistant engineer, include the qualifications required for appointment to grade 2, and in addition thereto not less than two years of experience in the practice of engineering of grade 2.

It will be seen, therefore, that while in grade 2 appointments must be made from those who have previously served in grade 1 or as transitman or draftsman in the subprofessional group, in grade 3 and the higher grades appointments may be made from those not previously in the city service, provided they have had the equivalent amount of professional experience demanded.

For appointment to grade 4, candidates must have the

minimum qualifications required for appointment to grade 3 and at least three years of experience in engineering practice of grade 3 standard. For appointment as a senior engineer, or grade 5, a person must have the minimum qualifications required for grade 4 and at least three years of experience in engineering practice of grade 4 standard. For appointment in grade 6, chief engineer and consulting engineer, the candidate must have the qualifications required for grade 5 and not less than three years of experience in engineering practice of grade 5 standard.

The hardest task of those engaged in framing the standards, apparently, was to define accurately the different grades of work corresponding to the grades of service.

Without attempting to reproduce in detail the description given in the report, it may be briefly summarized as follows: The duties of engineering assistants are to perform, under direction and supervision, apprentice work in field and office, including surveying and drafting, or inspecting or investigating minor engineering details. The duties of junior engineers are to execute definite instructions in a minor division of engineering work, such as designing or examining plans, preparing working or general drawings, inspecting or investigating engineering work and materials and compilation of data or directing a field party. Assistant engineers (grade 3) are required to exercise engineering judgment and assume responsibility required in the preparation of plans, designs, specifications and contracts, or directing or inspecting construction work on a minor section of a large engineering project or a major section of a small engineering project. The duties of grade 4, engineer, are to asume responsibility for a major division of work on a large engineering project, or the whole of a small engineering project. Seniors engineers (grade 5) occupy positions which require a high order of executive ability and specialized knowledge and are expected to assume responsibility for a less important engineering department or for an important engineering bureau, division or project, or to give independent expert or critical engineering advice of a high order. Chief engineers, or consulting engineers, are to occupy positions which require the highest order of executive ability and are to assume entire responsibility for all the engineering work in a department or for the most important engineering projects.

It should be said, also, that the duties in each grade are specialized. In grade 4, for example, the positions are distinguished as engineer, civil engineer, mechanical engineer, electrical engineer and sanitary engineer, and this specialization extends through all the grades to grade 6. In submitting this scheme for standardizing the City's engineering work, Director Tirrell, of the Bureau of Standards, comments as follows upon the plan for regularly promoting capable engineers according to their experience and ability:

One of the most serious obstacles to development of individual efficiency, at present, is the lack of any system which insures to the employee substantial recognition of his individual effort and accomplishment. Under present conditions, it is the usual experience that men enter public employment with a much higher degree of enthusiasm than they retain after a period of service, and that enthusiasm generally disappears completely in the course of a few years.

It is our belief that this condition of affairs is due, in a large measure, to the lack of any certainty of reward for increasing efficiency and devotion to duty. The specifications to be submitted by the Bureau of Standards provide for gradual periodic increases in compensation when work of employees is up to or above an approved standard.

In the lower grades, where work is largely of a routine character, annual increases are proposed up to a fixed maximum, wherever the service record of the employee is satisfactory.

In the higher grades, the dividing line being what is commonly considered the living wage, at or about $1200 a year, it is proposed that superior excellence will be made the basis of advancement, the theory being that in these higher grades the factors in making up an employee's efficiency, such as executive ability, quantity, quality and value of work, and the like, can be adequately measured. Distinctions can be made on the basis of comparative merit, and in the highest grades of the City service, where the value of a position can be closely appraised, it is proposed that increases in compensation be made upon appraisal as well as length of satisfactory service.

Protecting Newly Paved Streets

The City of Baltimore, Md., is spending many millions of dollars repaving its streets, and in order to give these pavements a fair chance of long and useful life, the city paving commission is making a direct appeal to property owners. The following notice is served on all property owners before paving operations are begun. It is proposed to serve the latter half of the notice again, when the pavement is completed:

BEFORE PAVING OPERATIONS ARE BEGUN

You are hereby notified that the street fronting this property is to be paved with improved pavement, and that the work will commence shortly after six weeks subsequent to the date of this notice.

All necessary underground construction for installing or repairing gas, water, electric and other subway structures must be done before the street is paved. After the new pavement is laid, no permits to cut trenches or to disturb the pavement will be issued. Notice to the above effect has been given by public advertisement.

DURING PAVING OPERATIONS

In order to assist this department in obtaining good work, and assisting the contractor in every way, the following suggestions are offered:

Do not allow unnecessary waste water to flow upon the streets, which interferes with and delays the work, and causes unnecessary expense.

Do not persist in passing "STREET CLOSED" signs, as they are put up to protect the work and should be obeyed.

Do not use a hose on a newly laid street, as the force of the water tends to tear out the filler between the blocks before it has become hardened.

If you have a complaint to make, do not argue with the foreman on the work; call up the Paving Commission's office.

AFTER PAVING OPERATIONS ARE COMPLETED

In order to assist in the proper care of improved pavements, in which every property owner and leaseholder should be interested, the following suggestions are made:

Do not allow your servants to throw soapy or polluted water on the streets. Have this emptied into a sink, so that it will be carried into a sewer.

Do not throw paper, trash, etc., in gutters, as it is not only unsightly, but it dams the water flow in the gutters, causing it to spread out over a large area of the street.

Do not build fires on improved pavements, as the heat is sure to destroy them.

Do not allow oils, gasoline, etc., to drop upon improved pavements, especially asphalt.

Do not chop ice off of improved pavements with sharp-edged tools, which penetrate the ice and injure the pavement below.

If you are a builder, pile your building materials on a platform; not directly on the street.

There is a law relating to the above suggestions. Be a law-abiding citizen.

Day's Work for a Locomotive Fireman—An average day's work for a fireman on a large locomotive is to handle 25 tons of coal at the rate of about five 15-lb. shovelfuls per minute of a 10-hr. day, according to testimony given before the Western Railroad Wage Arbitration Board in Chicago, on Dec. 18.

The City Tunnel of the Catskill Aqueduct

By Walter E. Spear*

SYNOPSIS—By far the most notable water-works tunnel ever driven, and, so far as is known, the longest single tunnel in the world, is the one lying deep in rock beneath New York City. This tunnel will ultimately deliver 500 millions of gallons daily, through uptake shafts, to the great arterial water mains of the city, connecting with Richmond Borough by means of a submerged pipe line beneath The Narrows. The tunnel proper is 17.7 miles long and from 15 to 11 ft. in diameter. Its depth in some places is 700 to 800 ft. below the surface of the ground, and it is never less than 150 ft. below the surface of sound rock. In some sections the unbalanced internal hydrostatic head is nearly 300 ft. The tunnel is lined with concrete throughout. The present article, which gives a general description of the tunnel and of the work preliminary to its construction, will be followed by others, taking up various phases of construction.

I--Preliminary Work

For the past three years, one of the greatest of engineering enterprises, the construction of the Catskill Aqueduct, has been carried on almost unnoticed through the heart of New York City. The City Tunnel, by which is known the pressure tunnel of the Catskill Aqueduct within the city limits, is to be a great trunk distribution main for the Catskill supply, and is in many respects unique in water-works practice. This tunnel is now approaching completion, and yet, with the exception of the residents in the vicinity of the shafts through which the work from Yonkers to Brooklyn is being done, the people of New York are hardly aware of its existence and but few have any idea of the magnitude of the undertaking.

As stated in Engineering News of Dec. 9, 1909, the original project of the Board of Water Supply in 1905 for the development of the Catskill sources provided, within the city limits, for the laying of pipe lines from Hill View Reservoir, at the terminus of the main aqueduct in Yonkers, to the boroughs of Queens, Brooklyn and Richmond. These pipe lines were to carry only 120 million gallons of water daily to those portions of the city; a plan for the delivery of the remainder of the Catskill supply of 500 million gallons per day was only worked out after several years of investigation. In 1909 a modification of the original plan was prepared, substituting for the pipe lines to the outlying boroughs of the city, a large pressure tunnel having a capacity of 500 million gallons per day, which was to be constructed deep in the bedrock to the great centers of population in the boroughs of Manhattan and Brooklyn. This tunnel was

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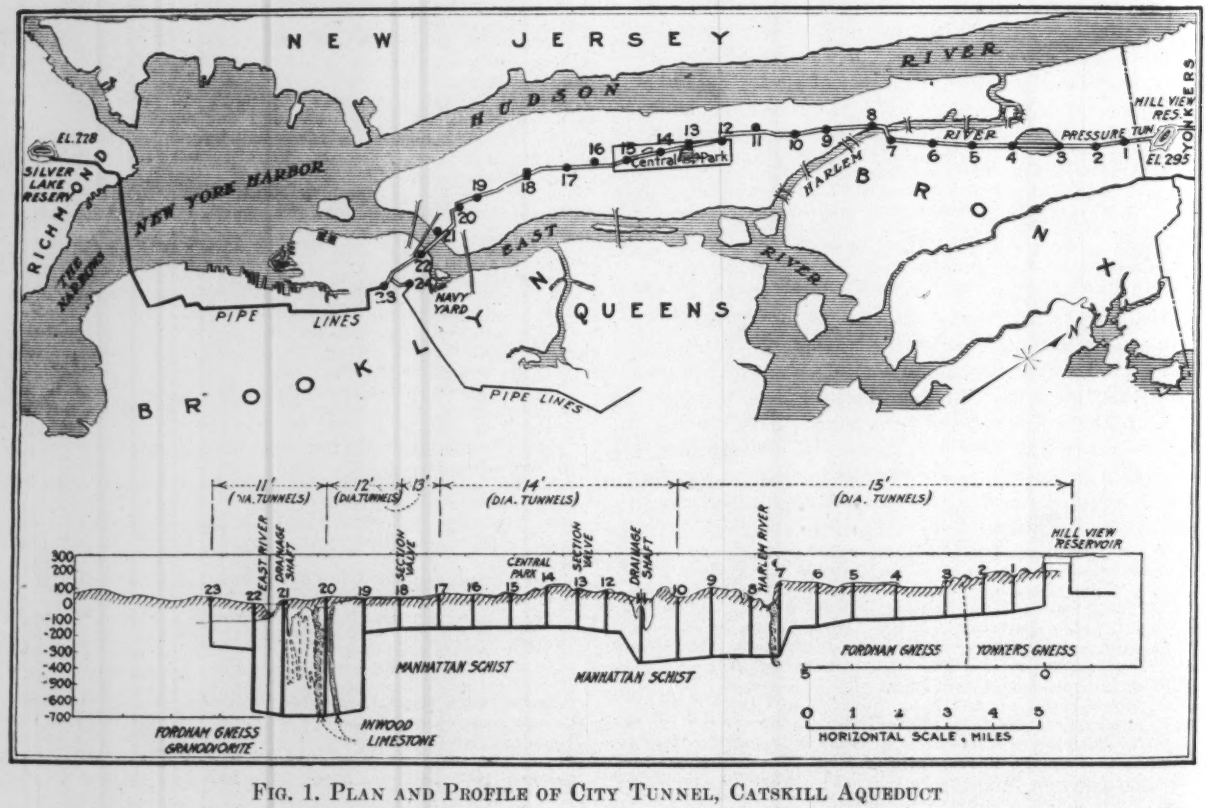


Fig. 1. Plan and Profile of City Tunnel, Catskill Aqueduct

to have frequent outlets connected directly with the distribution mains and was to be supplemented by large pipe conduits laid in the streets to carry a supply from the terminal shafts of the tunnel in Brooklyn to the boroughs of Queens and Richmond. The revised plan for the delivery of the Catskill supply was first passed upon by the Board of Estimate and Apportionment on Dec. 10, 1909; again approved by that body on July 1, 1910, during the next administration, upon a favorable report by Clemens Herschel, Francis L. Pruyn and J. E. Woodman (ENGINEERING NEWS, June 2, 1910), and finally authorized by the State Water Supply Commission on Oct. 20, 1910. Construction work began on the City Tunnel upon letting of contracts in June, 1911, and now, after three and a half years' work, the tunnel is about 98% finished, and there is every reason to believe that the entire City Aqueduct, including the pipe conduits and the reservoir in Richmond Borough, will be completed on schedule time, by the latter part of 1915, when the Catskill water may be delivered to all parts of the city.

GENERAL DESCRIPTION

The City Tunnel, though strictly limited to 17.7 miles of pressure tunnel now under construction within the city limits, properly begins at the downtake shaft of Hill View Reservoir, the distributing reservoir for the Catskill supply, which is situated in Yonkers, about one-third mile beyond the New York City line. From this reservoir, the tunnel is located beneath the streets and parks in the higher portions of the boroughs of The Bronx and Manhattan, crossing the East River at the lower end of Manhattan Island to the downtown business district of Brooklyn, a distance from Hill View Reservoir of 18.11 miles, including the short branch tunnel in Brooklyn to one of the two terminal shafts.

The tunnel has been driven everywhere at a depth of not less than 150 ft. below the surface of sound rock in order that, during construction, there might at all points be a sufficient depth of rock to insure good tunneling ground and a minimum ground-water infiltration, and that, in service, there might be ample cover to withstand the unbalanced internal hydrostatic head, amounting in some sections to nearly 300 ft., and a sufficient thickness of tight rock to resist any outward leakage from the tunnel. As seen in the profile, Fig. 1, the rock is at or near the surface over much of the line in the boroughs of The Bronx and Manhattan, and fully half of the line is but little more than 200 ft. below the ground surface. To secure the requisite depth of sound rock over the tunnel between the Harlem River and Morningside Park and on the lower East Side, where the rock has been eroded and disintegrated to great depths, the tunnel is much deeper. The granodiorite intrusion in the Fordham series beyond the East River slopes away to the south and east, and the increasing depth of saturated sands and gravels through which the shafts in Brooklyn were to be sunk to reach bedrock fixed the southerly limits of the tunnel about a mile and a half beyond the East River.

Inasmuch as the City Tunnel has frequent outlets connected with street mains, it is to serve primarily as a great trunk distribution main, and consequently does not have a uniform diameter. For some distance south of Hill View Reservoir, the tunnel has a finished diameter of 15 ft., but this diameter is reduced in Manhattan Borough by successive decrements of 12 in. until the finished diameter of the lower end of the tunnel leading to Brooklyn is only 11 ft. The lengths and limits of the various sizes of tunnel are indicated below:

Finished Diam., Ft.	Length of This Diam., Miles	Limits of Section of Tunnel of This Size From	To
15	7.71, including 0.34 mile in Yonkers	Hill View Reservoir in Yonkers	Shaft 10, St. Nicholas Park at 135th St., Manhattan
14	4.97	Shaft 10	Shaft 17, Bryant Park at 41st St.
13	0.86	Shaft 17	Shaft 18, Broadway and 24th St.
12	2.00	Shaft 18	Vicinity Hester and Orchard St., 1500 ft. south of shaft 20
11	2.57	Hester and Orchard St.	Terminal hafts in Brooklyn 23 and 24 at Flatbush Ave. and Schermerhorn St. and Fort Green Park, respectively

The tunnel is throughout a concrete-lined waterway having a circular section similar to other pressure tunnels of the Catskill Aqueduct, of which the Rondout and Wallkill siphons were described in ENGINEERING NEWS of Oct. 20, 1910, and June 1, 1911. In Fig. 2 are seen the dimensions of the standard unsupported section of the 15-ft. tunnel, which is typical of the other sizes. The City Tunnel has been driven for most of its length parallel with the strike of the rock, in formations having a nearly vertical dip and many seams and joints. Wide breakage has consequently occurred in many sections, and the average excavation has been generally beyond the payment line, giving an average cross-section of 5 to 10 sq.ft., or more, greater than that allowed for payment and a thickness of lining which averages over 23 in. In generally wet ground, the thickness of the lining was, in several instances, made 12 to 24 in. greater than that of the standard sections, to increase the watertightness and provide sufficient strength to resist heavy grouting pressures. The types of supported tunnel will be discussed later in taking up some of the details of construction.

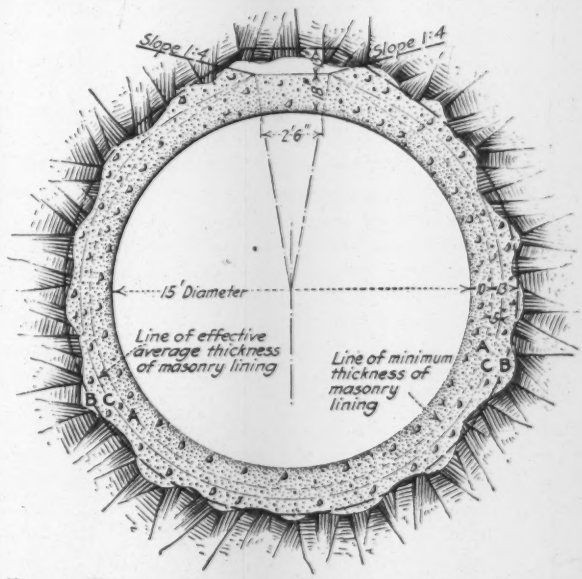


FIG. 2. TYPICAL STANDARD SECTION OF CITY TUNNEL, CATSKILL AQUEDUCT

Quantities per lin.ft.	Hydraulic elements
Excavation = 10.4912 cu.yd.	Area of waterway = 176.71 sq.ft.
Concrete = 3.7583 cu.yd.	Wetted perimeter, 47.12 ft.
Dry packing = 0.1879 cu.yd.	Hydraulic radius, 3.75 ft.

It is in the construction of the shafts that the City Tunnel is of greatest interest and differs most from the other pressure tunnels of the Catskill Aqueduct. The latter tunnels are simply inverted siphons and, of the shafts through which they were constructed, only that on

either end is a waterway, the intermediate ones having been plugged and refilled, whereas of the 24 shafts in the city, through which construction work is being carried on, 22 are to be finished as waterways, serving as outlets from the tunnel into the distribution mains. Furthermore, in the tunnels previously constructed, the intermediate shafts were made rectangular in section and were supported by timber, while in the City Tunnel, except for the three waterway shafts of special design, all shafts are circular in section and all but two were concrete lined from top to bottom as they were sunk. Even Shaft 1, a construction shaft to be refilled upon the completion of the tunnel, was so constructed. Only the section valve shafts, Nos. 13 and 18, which are roughly rectangular in section, were timbered temporarily. Shaft 11 in Morningside Park at 121st St., the drainage shaft for the northerly half of the City Tunnel, has no waterway and is almost identical with the circular drainage shafts on other pressure tunnels of the Catskill Aqueduct. Typical sections of the several types of shaft on the City Tunnel are shown in Fig. 3.

The most novel of the unusual features in the design of the City Tunnel shafts are seen in the details of the waterway shafts, and the devices for the control of the water discharged from the tunnel. Every precaution is being taken to prevent leakage from the upper portions of the waterway shafts where the shaft lining is generally backed up by less impervious rock than at greater depths. From a point 100 ft. below the top of sound rock in each shaft, one, and in some instances two, concrete-lined steel waterways are, therefore, to be carried to the surface and surrounded solidly with concrete, as seen in the vertical section of a 14-ft. shaft, Fig. 3. In 19 waterway shafts this waterway or riser is to have a finished diameter of 4 ft., and is to be capped at the top by a solid bronze tee of the same size, anchored into the concrete of the shaft. This tee is to be provided with a cover, through which access to the shaft and tunnel will be given, and with two 30-in. lateral outlets, from which pipe connections of the same size will be carried to the city mains. These bronze tees, with valves controlling the discharge, are to be placed in concrete masonry chambers constructed entirely beneath the surface of the ground in the streets and parks. The 30-in. valves on each lateral outlet are to be in duplicate and one of each pair, that next to the tee, is of solid bronze and is to be used only at such times as the other, a bronze-mounted service valve, is out of order. As a further measure of safety against the great volume of water and the comparatively high pressures which will be carried in the tunnel, another control, a special valve resembling in some features a needle valve, is to be placed in the waterway of the shaft at the bottom of each riser. This valve can be controlled either from the chamber or from a box on the surface about 100 ft. from the shaft, and is designed to close automatically when, through failure of the valves or waterways above, an exceptionally large flow takes place through the riser. Except for the shafts supplying water solely to high-service districts, pressure-regulating valves are to be placed in these valve chambers on bypasses around the service valves. By means of these pressure-regulating valves the pressure in the connections with the distribution mains may be maintained within any desired limits. In each of the three larger waterway Shafts 3, 23 and 24, two 6-ft. risers of a design similar to those in the other shafts are to be placed, and these are to be capped by correspondingly larger bronze tees having 48-in. outlets and valves of the same size.

It is estimated that shafts having a single 48-in. riser can discharge, in proportion to the effective head between the tunnel and the distribution mains, from 25 to 100 million gallons per day; and shafts having two 48-in. risers proportionally more. The larger shafts having two 6-ft. risers, Nos. 3, 23 and 24, can each discharge from 200 to 300 million gallons per day. In general, the waterway shafts are to be connected directly with the larger distribution mains through comparatively short pipe connections, but provision is made to concentrate a large proportion of the Catskill supply at appropriate points on the existing distribution system. Large outlets are provided at Shaft 10 by which 200 million gallons of water may be delivered, if desired, to the 135th St. gatehouse of the Croton system, where the trunk mains of that system begin. A still larger cross-connection with the Croton works is to be provided at Shaft 3, where 300 million gallons may be delivered through an 8-ft. connecting tunnel to Gatehouse 7 of the Jerome Park Reservoir. These large connections will insure a supply to lower Manhattan through the present aqueducts and mains, when, by means of the 66-in. valve across the tunnel at either of the so called section valve shafts, No. 13 in Central Park at 93d St. and No. 18 at Broadway and 24th St., the supply to the tunnel south of these shafts is cut off and the tunnel is perhaps pumped out for alterations or repairs. The water carried to the two terminal shafts in Brooklyn, Nos. 23 and 24, will be discharged into the large pipe conduits of the Catskill Aqueduct, which are to be connected with the smaller mains in the boroughs of Brooklyn, Queens and Richmond. The amount of water delivered to the city is to be measured by a Venturi meter placed in the tunnel just upstream from the first waterway shaft, No. 2, which is situated in Van Cortlandt Park at Mosholu Parkway.

With a flow equivalent to 575 million gallons per day (15% in excess of the average delivery), it is estimated with Hill View Reservoir at El. 295 (B. W. S. datum, mean sea at Sandy Hook), the gradient in the City Tunnel will be between El. 290 and 280 in The Bronx, between El. 280 and 260 in Manhattan Borough, and never less than El. 255 at the terminal shafts in Brooklyn.

Preliminary Work

Few projects have been so thoroughly investigated as the City Tunnel. Under the direction of the Consulting Geologist, Dr. Charles P. Berkey, a general location was first selected, which, so far as possible, avoided the weaker and the most deeply eroded rocks, and which crossed at the most favorable points the known lines of the weakness, where seamy or decayed rock was to be anticipated. Extensive deep core borings were then begun and were carried on under four separate contracts during a period of over three years for the purpose of fixing the alignment and grades. Most of the shallow borings were made with shot drills of the Terry core-drill type, with which cores 3 in. and 1¾ in. in diameter were secured. On the remainder of the work, including the river borings, diamond-drill machines were used and cores from 1¾ to $1\frac{3}{16}$ in. in diameter were recovered. The larger shot-drill cores were much more satisfactory in interpreting the geological structure, but the diamond-drill machines made better progress below 200 ft. in depth and were able to

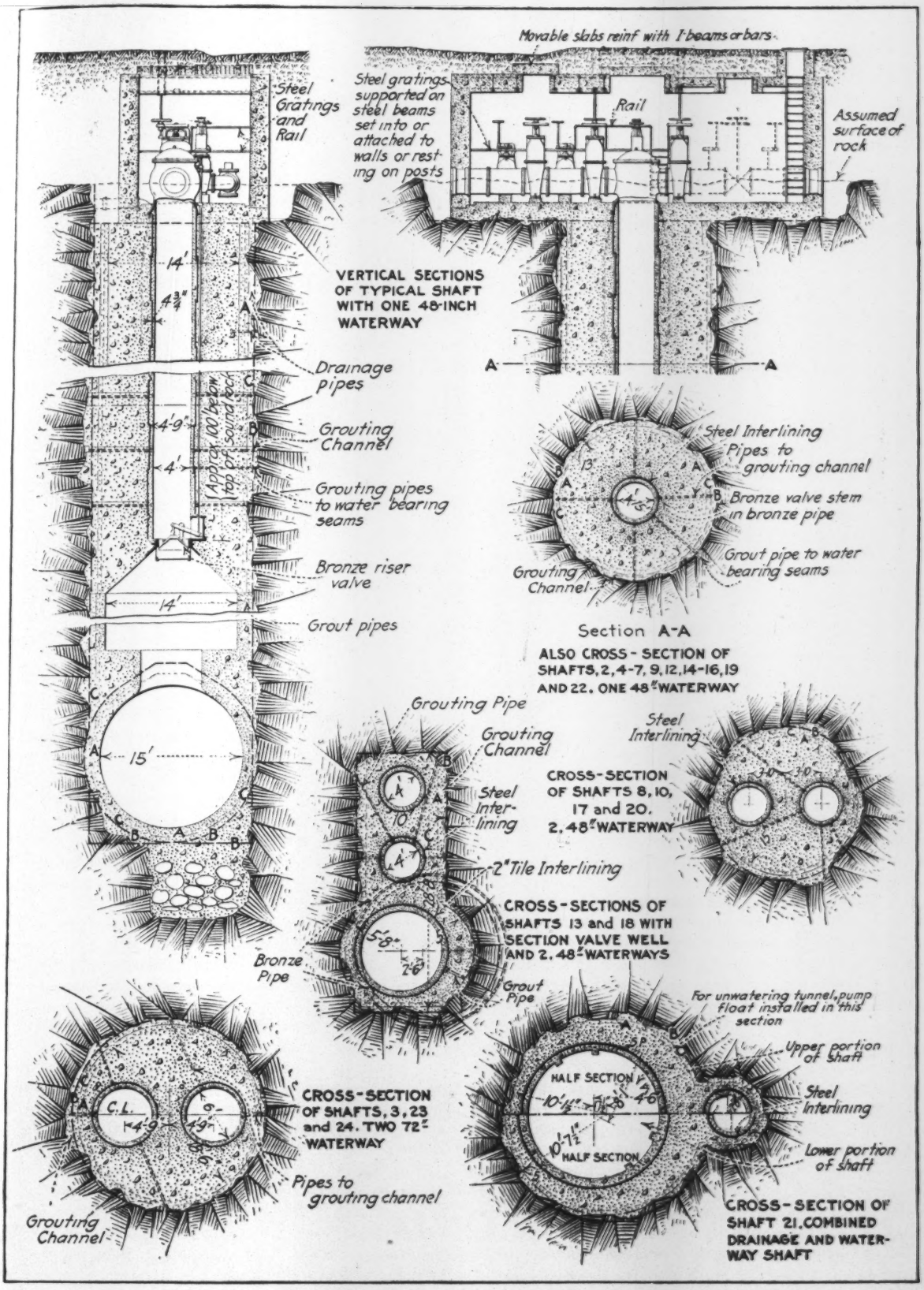

Movable slabs reinf with I-beams or bars
Steel gratings supported on steel beams set into or attached to walls or resting on posts
Rail
Assumed surface of rock
Steel Gratings and Rail
VERTICAL SECTIONS OF TYPICAL SHAFT WITH ONE 48-INCH WATERWAY
Drainage pipes
Grouting Channel
Grouting pipes to water bearing seams
Bronze riser valve
Grout pipes
Steel Interlining
Pipes to grouting channel
Bronze valve stem in bronze pipe
Grout pipe to water bearing seams
Grouting Channel
Section A-A
ALSO CROSS-SECTION OF SHAFTS, 2, 4-7, 9, 12, 14-16, 19 AND 22, ONE 48" WATERWAY
Grouting Pipe
Grouting Channel
Steel Interlining
CROSS-SECTION OF SHAFTS 8, 10, 17 and 20, 2, 48" WATERWAY
2" Tile Interlining
CROSS-SECTIONS OF SHAFTS 13 and 18 WITH SECTION VALVE WELL AND 2, 48" WATERWAYS
Bronze Pipe
Grout Pipe
For unwatering tunnel, pump float installed in this section
Upper portion of shaft
Steel Interlining
Lower portion of shaft
HALF SECTION
HALF SECTION
CROSS-SECTION OF SHAFT 21, COMBINED DRAINAGE AND WATERWAY SHAFT
CROSS-SECTION OF SHAFTS, 3, 23 and 24, TWO 72" WATERWAY
Pipes to grouting channel
Grouting Channel

FIG. 3. TYPICAL SECTIONS OF SHAFTS ON CITY TUNNEL, CATSKILL AQUEDUCT

reach depths of 600 to 700 ft. through alternating strata of solid and decayed rock, which the shot drills failed to penetrate. The most effective of these diamond-drill machines was the Sullivan "H" hydraulic-feed machine.

The critical sections of the tunnel, which received most attention, were at the Harlem River crossing, in the Manhattan Valley at 123d St., and on the lower east side of Manhattan from the Bowery to the East River, the last a region of extensive movement about which little was known. Much exploration was also necessary in Brooklyn where the rock lies at a considerable depth below the surface. In these sections, core borings were made, at several localities, at intervals of 100 ft., and many were carried to tunnel grade. At other portions of the tunnel line, however, where the general elevation of the surface of the rock was fairly well known, a sufficient number of borings were made here and there, where the rock was covered by drift, to establish the elevation of the rock floor and, except at shaft sites where explorations were made to tunnel grade, the borings penetrated only 20 ft. into sound rock. From the head of Van Cortlandt Park to the Harlem River, the construction of the pressure tunnel of the New Croton Aqueduct had demonstrated, 25 years ago, the feasibility of constructing a deep tunnel in that section, so that but few borings were needed there. Altogether 201 borings, aggregating 46,052 ft., were made as follows:

Depth in Ft.	No. of Borings	Aggregate Depth, Ft.
Less than 100	68	5,500
From 100 to 300	51	7,224
From 200 to 300	33	7,951
From 300 to 400	13	4,549
From 400 to 500	10	4,341
From 500 to 600	1	542
From 600 to 700	8	5,435
Over 700	17	12,510
Total	201	46,052

The total cost of these borings, representing the contract payments for the full depth of all holes, as well as the casing and paving repairs, was $207,651, which corresponds to an average cost of $4.51 per ft.

When the general location of the tunnel was finally decided upon, surveys were made of all prospective shaft sites and locations adopted which promised the least interference with the surface topography, and with existing or proposed subsurface structures, and which, at the same time, offered the best opportunities for the laying of the necessary pipe connections to the distribution mains. Upon the organization of the engineering force for the supervision of construction, the final alignment of the tunnel was run out on the surface with great care and monumented. The tunnel was so laid out in the streets that, except at a few corners, the "B" or payment line was not nearer than 6 ft. to the building line. This was done in order to safeguard the tunnel from deep borings on adjacent lands for elevator wells, water-supply or other purposes, and to be sure that the tunnel excavation would not encroach on private property. All appreciable changes in direction were made with curves of 50-ft. radius. These alignment surveys in the busy downtown streets presented many difficulties, and some of the work had to be done at night or in the early morning, when there was the least traffic in the streets. The center line of the tunnel thus established was subsequently reproduced in the tunnel by much the same methods as outlined in ENGINEERING NEWS of June 1, 1911, and so well was the entire work done by the section engineers and their assistants that, in no instance, did the headings meet within more than 6 in., and fully half of them met within 2 in.

REAL ESTATE

But little land had to be acquired for the City Tunnel, since it was located for almost its entire length through public property in the parks and streets. The tunnel could have been shortened by placing it, in part, beneath private property, but the expense of the easements would doubtless have exceeded the saving in cost of construction and such a location was considered unwise, since it might expose the tunnel to serious damage from deep borings. Of the 17.7 miles of tunnel within the city limits, it was necessary to acquire permanent easements for only 1027 ft., comprising a right-of-way 25 ft. in width between Lind and Sedgwick Ave., near Highbridge in The Bronx, and a right-of-way of the same width on the East River water front at the foot of Bridge St., Brooklyn. So far as possible the shafts were also placed on city property, but three of the 24 shafts, Nos. 20, 21 and 23, could not be so located, and property had to be secured adjacent to two other shafts, Nos. 7 and 16, to provide construction areas. Altogether, the fee in 0.259 acre of land was acquired and temporary easement in 0.057 acre secured.

The cost of all real estate is summarized below:

Easements for tunnel, 1027 ft.	$1,400
Fee in property for shafts, 0.259 acre	311,513
Temporary easement for shaft construction, 0.057 acre	1,500
Expenses of condemnation	35,904
Total	$350,317

Subways for Public-Utility Pipes and Wires in Chicago Streets

The subject of improved means for accommodating the public-utility pipes, conduits, wires, etc., in the downtown district of Chicago has been studied by a special Commission on Downtown Municipal Improvements, composed of aldermen and representatives of the Association of Commerce. Louis A. Dumond is Secretary and Engineer of the Commission. The information collected was submitted to Alvord & Burdick, consulting engineers, of Chicago, who used it as the basis of an investigation and recently presented a report to the Commission from which the following information is taken.

The general purpose of subways for pipes and wires is to provide better accommodation for the numerous and complicated pipe and conduit systems under the congested streets of the downtown district, and to eliminate the present continual disturbance of the street paving for access to these various utilities. This disturbance not only interrupts traffic but also seriously affects the life and condition of the paving, with loss of money on the original construction and continual patchwork repair. The proposed subway or underground railway system has an important relation to the question of the underground utilities.

The report shows that the district bounded by Lake Michigan, the Chicago River and 12th St. has 21 miles of street with 120 acres of pavement surface valued at $2,000,000. Beneath these streets are 220 miles of utility pipe and conduit lines (including those municipally owned), exclusive of an equal or greater mileage of service connection. The pavement openings for the maintenance and betterment of these utilities range from 2000

to 500 per year, and the aggregate area of these openings in 1913 was over 10 acres, or equivalent to a 48-ft. street over two miles long.

It is estimated that the occupancy of the district will be increased at least 100% within 15 or 20 years, and ultimately 300 or 400%. The available space for utilities is at present occupied, but with orderly arrangement it is sufficient to meet the ultimate requirements.

The various utilities are listed as follows: (A) Municipal—water pipes, 34.6 miles (including lines in alleys); sewers, 23.6; city wires, 5.3; total, 63.5. (B) Private corporations—Peoples Gas Light & Coke Co., 94.9 miles; Commonwealth Edison Co., 25.3; Chicago Telephone Co., 21.2; Western Union Telegraph Co., 5.7; Postal Telegraph Co., 6.5; total, 156.6. Grand total, 220.1 miles of utilities in 20.8 miles of street. Many streets have five or six, and some even as many as nine gas pipes, while even the narrow streets have from two to four pipes, due partly to the growth of the city and partly to the fact that the present company is a consolidation of several former companies. The sewers are on the combined system, and as most of them were built many years ago, they are of insufficient capacity to drain the district and carry off the water during heavy rainstorms. An entirely new system of sewers, with separate lines for sewage and rain water, is advocated by C. D. Hill, Chief Engineer of Sewers.

Some streets have as many as 18 separate sub-surface lines, laid out in a most complicated manner, as newer ones have had to avoid previous lines and other obstructions. At street intersections there is further complication due to the connections of intersecting lines and to the vaults for valves and hydrants. Some intersections have as many as 41 manhole covers. It is the obstructions of this kind which are most serious in the congestion of the utilities.

The pavement torn up to provide access to the underground utilities was equivalent to 3% of the street mileage in 1913, and 9% in 1914, while 57 and 72% of this was occasioned by repairs in these two years. Of the total yardage torn up, the municipally owned utilities were responsible for 35 and 32%, respectively.

Foreign experience indicates that utility galleries or subways as applied to streets where the investment in utilities is already made are not financially practicable, but that such galleries are warranted where new streets are opened. The pipe subways of Paris and several English cities were described in ENGINEERING NEWS, Mar. 14, 1907. The practice in London is for the municipality to build them, renting the space to the private corporations. London has eight miles of galleries and 50 years' experience in their operation. Quoting from the report:

> Chicago conditions differ from those of London in the height of the buildings, and the greater use of utilities. Further, there is the important fact that all the streets in this district of Chicago must be opened in the near future for the construction of a new sewer system (estimated to cost from $1,000,000 to $2,000,000), and probably for a high-pressure fire-protection system. A number of them must be opened also for the building of transportation subways, which work would be accompanied by extensive changes in other utilities. These latter subways affect not more than 10% of the streets for the initial routes and 33% for ultimate future extensions.

As to the financial aspect, the report points out that in the end the people must pay for the adequate accommodation of the utilities, and that therefore a coördinated plan for the accommodation of all at the least cost will give the most economical result. If utility galleries are to be financially practicable they must permit of a saving sufficient to warrant their cost.

The saving will include the following: (1) Cost of street openings, now amounting to $200,000 to $400,000 annually; (2) reduction in cost of pavement maintenance; (3) longer life for pavements; (4) reduction in operating cost of utilities; (5) reduction in cost of future extensions; (6) reduced leakage of water and gas; (7) the value to the public of good streets and decreased interference with travel.

The costs will include the fixed charges on the following: (1) The expenditure for galleries; (2) the cost of moving the utilities to the galleries, taking into consideration the fact that the greater part of the present investment would be economically abandoned; (3) the cost of cutting and reconnecting the service lines. The costs and savings can be determined only by further investigations. A rough estimate indicates that the reproduction cost of the existing substreet utilities (public and private) is between $10,000,000 and $13,000,000. It is to be remembered also, that further large investments must be made in the revision of utilities, as noted above.

The saving in cost by the exclusion of sewers and gas mains has been considered, the former on account of requiring very infrequent tearing up of streets and the latter on account of fear of explosions. The saving would not be very great, however. Long experience in London indicates that with proper precautions and ventilation there is little liability of explosion, and as explosions have occurred in Chicago streets they might be no more frequent in utility galleries.

The construction of underground galleries or subways for utilities has been discussed in a number of American cities, but according to the report no such subways have been built, except on one short street in New York, and this is not occupied.

There may be either a single subway in the center of the street, or one near each curb line, and the latter arrangement is considered the more practicable. In many cases the alleys might be used with advantage, but as a rule these run in one direction only. The use of subsidewalk space for the galleries also offers important advantages. While much of this space is occupied by abutting property, in about 10% of the Chicago downtown district the city owns the streets to the property lines, and issues revocable permits to the occupants. In the remainder of the district, it has an easement to the property lines for street purposes, and it has been held by legal authority that the use of this subsidewalk space for utility subways constitutes legitimate street use.

The conclusion of the report is that further study and investigation are necessary before any definite plans can be adopted. If it is not found practicable to at once install a comprehensive system of utility galleries for the downtown district, attention should be given to the opportunity for successive installations in connection with other improvements, such as the Michigan Boulevard link, the 12th St. widening and the transportation subways.

Finally, the report says, "as an economic proposition, the saving to the utilities by the use of subways, plus the value of the subways to the public in relieving present inconvenience, must be sufficient to pay the fixed charges and maintenance on a system of subways, plus the cost of placing the utilities' property in the subways."

The Columbia Highway in Oregon

By Henry L. Bowlby*

The only break in the wall formed by the Cascade Mountains from British Columbia to California is where the Columbia River flows through to the Pacific Ocean. This is the natural route for all transportation from the Pacific Coast to the interior of Washington and Oregon. One of the best railroad grades in the world lies on the north bank of the river, the roadbed of the Spokane, Portland & Seattle Ry. On the south bank, the Oregon-Washington Railroad & Navigation Co.'s tracks have been in operation since 1882. In the last few years a large sum of money has been expended in relocation and betterments. The United States Government has expended many millions of dollars on channel improvement in the river with the expectation of having by the end of the present year open water from the Pacific into central Washington. The gorge of the Columbia River is even the route of the air currents from the Pacific that make climatic conditions favorable to the great fruit belt just east of the Cascades.

Yet is has been impossible to drive a vehicle along the Columbia River continuously for any great distance. The only mode of transportation has been the railroad. This condition will be changed in July, when the State of Oregon expects to celebrate the opening of the Columbia Highway from Pendleton to the sea.

Figs. 1 and 2. Columbia Highway in Oregon; a 43-Ft. Dry Masonry Retaining Wall on Loop on Bugbee Mountain

Beginning of the Undertaking—The first real movement for better roads in Oregon was started in February, 1913, upon the occasion of the visit of the Oregon Legislature as a body to Maryhill, as the guests of Sam Hill, a well known good roads advocate. As a result of this trip, a state highway department was created and a state highway engineer employed.

Between July, 1913, and November, 1914, $930,000 was expended on the construction of a highway from the Pacific Ocean along the south bank of the Columbia River, through the counties of Clatsop, Columbia, Multnomah, Hood River and Sherman.

Plans—Present plans provide for the expenditure of $670,000 more on this road during the present year. An entirely new road is not intended, but this expenditure of $1,600,000 will construct 97 miles of wholly new grade, and 19 miles of pavement. The types of pavement used are concrete and Warrenite.*

Grade and Curvature—The Columbia Highway has been laid out and constructed with a 24-ft. roadbed, both in cuts and fills. The maximum gradient is 5%, with a minimum radius of curvature of 200 ft. In specially difficult places, the minimum radius of curvature has been reduced, but in no case to less than 100 ft. Whenever a radius of curvature less than 200 ft. has been used, the gradient has been compensated by reducing the grade on the curve 1% for each 50 ft. of reduction in the radius of curvature.

Scenic Features—In the location of the road special attention has been given to the development of the scenic features of the Columbia River Gorge. Beginning at Seaside, the highway parallels the beaches for 12 miles, and then continues over low land for 14 miles to Astoria. From Astoria, a 28-mile section is under contract, 80% completed, and will cost $275,000 for the grading, drainage and bridges.

On this section is found one of the most pleasing features of the highway. At an elevation of 750 ft. above the river, on Bugbee Mountain, the road bursts out of the dense forest of Oregon fir, and descends on a 5% grade along the face of the cliff. The view from the summit, covering a distance of 40 miles or more in all directions must be witnessed to be appreciated.

The road descends 600 ft. on the maximum grade. The development includes four complete "hairpin" curves, one below the other. The roadbed at the end of one of these curves is held by a dry rubble masonry retaining-wall, 43 ft. high, built on the circumference of a circle of a radius of 112 ft., and a central angle of 210° (Figs. 1 and 2).

The next contract is for 39 miles of road in Columbia County. The cost of grading, draining and building the bridges on this section is $330,000. The next section of

*State Highway Engineer, Salem, Ore.

*A patented kind of asphaltic concrete laid by Warren Brothers Co., Boston, Mass.

FIG. 3. REINFORCED-CONCRETE VIADUCT 860 FT. LONG, EAST OF THE MULTNOMAH FALLS

new construction is in Multnomah County east from Portland. This stretch of 16 miles to the Hood River County line is called the Waterfalls section of the Columbia Highway, and it is the richest in natural scenery.

There are nine large waterfalls at whose base the new highway is located. Unique reinforced-concrete bridges have been built across all waterways.* Two of these bridges are of a design novel in America. There are 1200 ft. of reinforced-concrete viaduct on this section which carries the highway alongside and over the O.-W. R.R. & N. Co.'s railroad track (Figs. 3-4). This construction was necessary because the entire mountain-side is an enormous slide. The viaduct has a clear roadway of 17 ft., and cost complete for the 1200 lin.ft., $32,000. There is one tunnel 120 ft. long through a rock point. The construction of the 16 miles, including grading, drainage and bridges, will be $400,000. Above Rooster Rock the new road runs out and around Crown Point, where the river is almost perpendicularly below, a distance of 720 ft.

*See article in "Engineering News," Dec. 10, 1914.

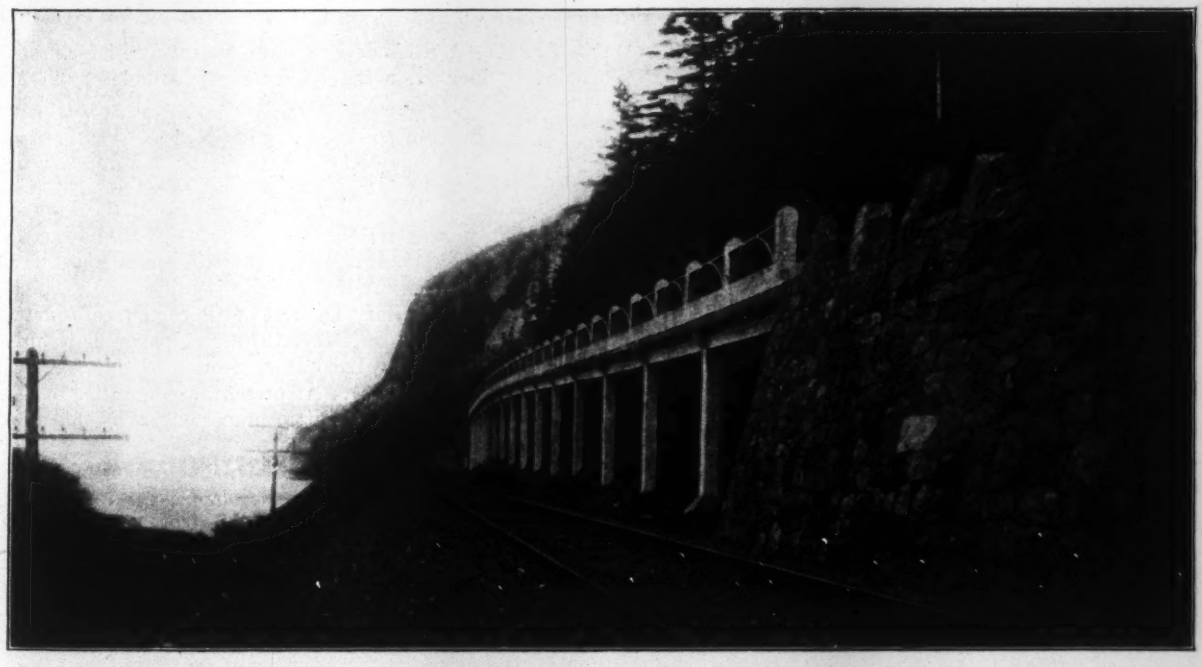


FIG. 4. DRY-RUBBLE RETAINING WALL AND REINFORCED-CONCRETE SIDE HILL VIADUCT, MULTNOMAH

The radius of curvature around this point is 100 ft., and the central angle 200°. A reinforced-concrete retaining-wall, with parapet and sidewalk, is being constructed on the outside of this curve.

The view of the cañon of the Columbia from Crown Point is superb. On a moderate scale it is as grand as the Colorado River Cañon.

There are two arch concrete bridges in this section, one at Latourelle of three 80-ft. spans, and one at Shepherds Dell of 100-ft. span. Over these bridges the roadway is 16 ft. 10 in. wide. The cost of the two bridges was $32,600.

The road descends from Crown Point on a 5% grade with a development similar to that on Bugbee Mountain, using four "hairpin" curves, or loops.

Six miles of road in Hood River County are now under contract, and will cost to grade and drain $75,000. One mile more in this county, around Mitchell's Point, will

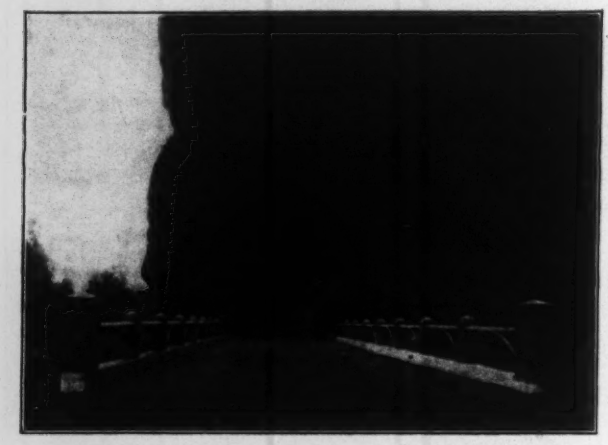


FIG. 5. CONCRETE BRIDGE AND TUNNEL AT ONEONTA GORGE, MULTNOMAH COUNTY

be built early this year at a cost of $50,000 for grading. This is a grand mile. There will be three tunnels and nearly the entire distance will be in solid rock.

In Sherman County, six miles of new highway built last year complete the missing links in the Columbia Highway from Pendleton to the sea. This does not mean that within a year there will be a new road the entire distance of 360 miles, but, as noted before, 97 miles will be newly located and constructed road, and the remaining 263 miles are passable.

There are two other trunk state highways in Oregon, the Pacific Highway, and the Central Oregon Highway, on which a great deal of work has been done the past year.

The improvement of the Columbia Highway has been done by the State Highway Commission. The author is State Highway Engineer; S. C. Lancaster and L. Griswold are Assistant Highway Engineers. Mr. Lancaster has charge of the Columbia Highway from Portland east and Mr. Griswold from Portland west.

A Rapid Track-Laying Record in South Africa is reported in the "Cape Argus," in which the statement is made that on the line from Prieska to Upington the first train ran over the road on Nov 16. Track laying on the road, 142 miles in length, began on September 9, so that the whole work of track laying occupied 68 days. This, of course, is far lower than some of the rapid track-laying records made in the Northwest during the railway construction boom of the late '80s and early '90s. It is claimed that this constitutes, however, the most rapid track-laying record to date in South Africa.

Analytical Methods for the Control of Sewage-Treatment Works*

The latest edition of "Standard Methods of Water Analysis" of the American Public Health Association supplies sanitary engineers, chemists and bacteriologists with a nearly complete set of analytical procedures, many of which are of assistance to sewage-works operators. It is not, however, stated which of the many tests described are most useful for the practical purpose of sewage-works operation. Certain tests are, therefore, submitted herewith and their use and relative value commented upon.

Different works obviously require the use of different sets of tests for their study and control, based upon peculiar needs and conditions and, therefore, no definite set of tests can be laid down to suit all conditions. Hence, the outline of tests submitted is to be considered as broadly suggestive and not as a specification for every conceivable condition.

Laboratory facilities are frequently limited and help lacking, so that it is impossible to carry on extensive investigations. The tests recommended are, therefore, limited to the most important and useful, realizing that where opportunity exists other work will be carried on, as in the case of testing stations.

COLLECTION OF SAMPLES—Composite samples are recommended, with the size of the individual portions proportional to the rate of flow of sewage at the time of sampling. Crude sewage should be sampled at more frequent intervals than effluents of refined processes of treatment.

It is of great importance for the proper interpretation of published data, that in connection with reported analyses a statement be made of the frequency of sampling and whether the figures given are, for instance, the average of certain chance samples or the averages of continuous composite sampling.

COMMENTS ON TESTS RECOMMENDED

TEXT X—By this designation is meant a test for measuring by incubation the avidity of the sample of sewage or effluent for dissolved oxygen or its equivalent. The Royal Commission on Sewage Disposal developed a technique for such a test (see ENGINEERING NEWS, Dec 19, 1912, Jan. 9 and Feb. 27, 1913). Another method was developed by C. B. Hoover and is in use at the sewage-treatment works at Columbus, Ohio (see ENGINEERING NEWS, May 28, 1914, p. 1187) and still another has been devised by Dr. Arthur Lederer and is in use in the laboratories of the Sanitary District of Chicago (see *Journal of Infectious Diseases*, May, 1914, and paper to be presented by him to the Laboratory Section of this Association at these meetings). At present, a committee of the Laboratory Section is about to propose a provisional procedure for such a test.

This test is considered to be of prime importance; but as there is, as yet, no definitely recognized technique nor name it is here indefinitely designated by the symbol X.

For the present, it is *urgently* recommended that some

*Slightly condensed from the Progress Report of the Committee on Sewage-Works Operation and Analytical Methods, presented to the Sanitary Engineering Section of the American Public Health Association, Jacksonville, Fla., December, 1914. The names of the members of the committee appear at the end of the report. Extracts from the section of the report dealing with sewage-works operation will be given in a later issue.

form of the test be used even though all workers may not agree on the exact procedure to adopt.

TEST Y—By this designation is meant a test for measuring not only the amount but also the condition and physical characteristics of the suspended matter in sewage.

Suspended matter was first determined by the difference in the weight of the residue upon evaporation of a portion of the sample filtered through paper and another unfiltered. At the present time, the Gooch crucible is generally used to obtain the weight direct. In both procedures the organic portion of the suspended matter was estimated by determining the loss of weight upon ignition. The Royal Commission on Sewage Disposal attempted to devise a method for determining the amount of suspended matter by means of the centrifuge. In the works of the Emschergenossenschraft a simple field method is in use for determining the bulk of the settleable matter by subsidence in graduated conical glasses.

None of these methods, however, furnish information concerning the size, physical condition or other characteristics so essential to know in the preliminary treatment of sewage. One of the reasons for this is the small size of the sample examined and the difficulties of obtaining a representative portion for analysis; for the inclusion or exclusion of a large-sized piece of suspended matter in a small sample will cause large variation in the result obtained.

The efficiency of all preliminary processes depends upon the removal of the settleable solids and, therefore, a test to measure them is of great importance.

It is, therefore, recommended that in sewage-works operation some procedure for the determination of suspended matter be used and that analysts be argued to devise a technique to supply the information required.

NITRATES—This test is very useful because its place in the interpretation of analyses is well understood and it is a delicate indicator of the activity and efficiency of oxidation processes. Moreover, the results are available within a comparatively short time after the samples are taken.

DISSOLVED OXYGEN—This test is of great value because of the light it throws on the condition of the receiving body of water. Its use is recommended also in connection with effluents from oxidation processes.

The amount of dissolved oxygen present in a stream at any particular place or time, or in an effluent, should, however, be considered in connection with either the results of the test designated X [above] or relative stability [below] for the presence in the sample of sufficient decomposable matter might exhaust in a short time the dissolved oxygen found by the analysis.

RELATIVE STABILITY: METHYLENE BLUE—This test has a definite value in connection with the dissolved oxygen and nitrate tests in explaining the records of past operation, but its greatest value is as a control for small works. Obviously, many small works cannot be kept under the continual observation of a trained chemist or engineer, and in such cases the relative stability test can be readily made by an attendant incapable of the more elaborate procedures. Under these conditions relative stability is of primary importance and its daily use is strongly recommended in preference to occasional tests of other kinds.

Caution should be used in regard to the relative stability of tank effluents, sterile effluents or effluents containing certain industrial wastes.

TESTS OF SLUDGE—(a) Specific gravity; (b) percentage moisture; (c) percentage of the dry residue that is volatile; (d) reaction—alkalinity or acidity.

These tests made on sludge, especially sludge from two-story tanks and separate sludge-digestion tanks, are of great value in operation, as they interpret the biological digestion of the organic matter. The reaction test is particularly important as an aid in detecting the cause and pointing out the remedy for poor sludge production. It has been found that tanks producing bad sludge can be made to produce good sludge by adjusting the reaction from acid to alkaline.

In sludge obtained from fine screening it is advisable to determine the weight per unit volume and percentage moisture.

BACTERIA: PRESUMPTIVE TESTS FOR B. COLI—For sewage-treatment works intended solely to prevent nuisance in water courses, tests for bacteria are superfluous. They are, however, of the utmost importance in cases where the works are intended to protect sources of water-supplies or shellfish layings. It is unnecessary to carry on the confirmatory tests for B. coli used in water-works control, as the presumptive tests are much simpler and more conservative.

The formation of gas or the red colonies having appearance of B. coli on litmus lactose agar at 37° are both in successful use for this purpose. When used, the test should primarily be made on the receiving body of water and secondarily on the effluents from disinfection processes.

TESTS OF CRUDE SEWAGE FOR COMPARISON—For the purpose of record and comparison it is advisable to make at intervals tests upon composite samples of the crude sewage received at the works. These tests should indicate the character, condition and strength of the sewage.

It is recommended that at least the following determinations be made: (1) Test for suspended matter called Y above; (2) test for avidity for oxygen called X above; (3) nitrogen as organic; (4) nitrogen as free ammonia; (5) chlorine. Special cases may require other tests to show the characteristics of the sewage.

Tests when applied to sewage and effluents are of value as tools for operating control, but as a measure of sufficiency of treatment they do not always supply adequate information. This is on account of the difficulty of formulating precise standards for effluents discharged into different kinds of receiving bodies of water, and, therefore, the final criterion of sufficiency of treatment must logically rest in the effects produced upon the receiving body of water considered in the light of expediency and local needs. Investigations of the effects of effluents on bodies of water are, therefore, urgently recommended.

The committee requests engineers and chemists in charge of sewage-treatment works to send their views and criticisms of the outline of tests to the Chairman of the committee in order that complete data may be collected and a final report submitted next year.

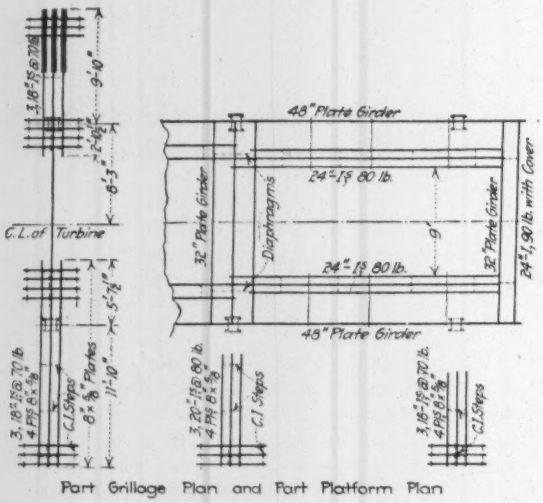
W. L. STEVENSON, Chairman, 412 City Hall, Philadelphia, Penn.;
C. B. HOOVER, Columbus, Ohio;
H. C. MCRAE;
LANGDON PEARSE, Chicago;
GEORGE C. WHIPPLE, New York City.

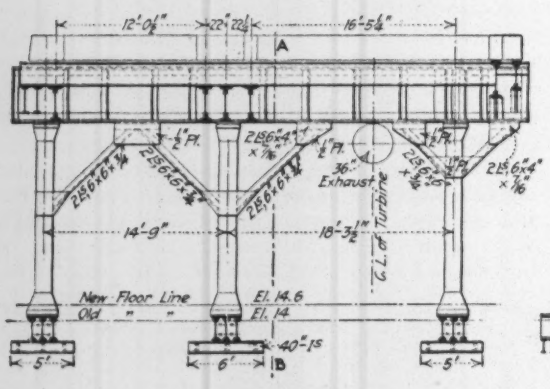
Structural Steel Supports for Large Steam Turbines

SYNOPSIS—Designs of well braced elevated steel structures for supporting horizontal turbo-generators of 15,000-kw. to 30,000-kw. capacity, weighing up to 500 tons each. Low fiber stress used. Concrete placed between parallel steel members. Two types of platform: first, where load falls directly on main girders; second, where load is transmitted to main girders through a secondary system of beams and girders. Difficulties of problem increased by limited space, in all but one instance.

PUBLIC SERVICE ELECTRIC CO. OF NEW JERSEY

When the extension to the Marion, N. J., power station of the Public Service Electric Co. of New Jersey, was built, in 1913, space was left for future 10,000-kw. vertical turbines. When, however, additional electric capacity was required, it seemed wiser to install a 22,000-kw. horizontal turbine. Something of a problem was encountered in fitting this larger unit into the space available. In order to make the most of this space, and to give a convenient arrangement of auxiliaries, it was decided to construct a steel framework to support the turbine. This would allow placing the condenser underneath the turbine and longitudinal to its axis.





The steel foundation consists of a platform with a large opening for ventilating ducts at the generator end and another opening on the turbine end for exhaust connections. The principal problem in the design was to make the structure as rigid as possible. To do this, not only were very heavy members employed, but concrete was poured between all parallel members. Space was left between the flanges of horizontal steel members to facilitate filling with concrete.

The turbine was leveled up on the baseplate with a layer of lead about ¾ in. thick. Clay was placed around the cast-iron base to confine the lead which was melted and poured in. The turbine was first leveled up just above the platform and held in place by steel wedges.

The cast-iron baseplate of the turbine proper was assumed to have no stiffness, as regards bending. The steel girders upon which the baseplate rested were designed for the full weight of the turbine including the weight of the baseplate, allowing 100% for impact, with a maximum allowable deflection of 0.01875 in., to safeguard against heating of bearings and prevent blade interference. The maximum fiber stress in the steel was taken as 4000 lb.

All horizontal members were securely tied together with cast-iron separators and steel diaphragms, and all riveted connections were made 50% stronger than standard requirements for equivalent members, by the addition of more rivets, heavier connecting angles and plates. This was done for greater rigidity of joints against vibration.

The columns are of the standard box-section type. The two middle columns, which carry the heaviest load, are formed of two 12-in., 20½-lb. channels with four 16½-in. plates; the corner ones have but two plates. The height of the columns is about 16 ft. 5 in. The inside of these columns was filled with a rich concrete, to further insure against vibration. They are braced with kneebraces.

The spaces between the brackets and the 48-in. main girders of the platform are also filled with concrete. There is also intermediate bracing between the columns and the cross girders which frame into the main girders.

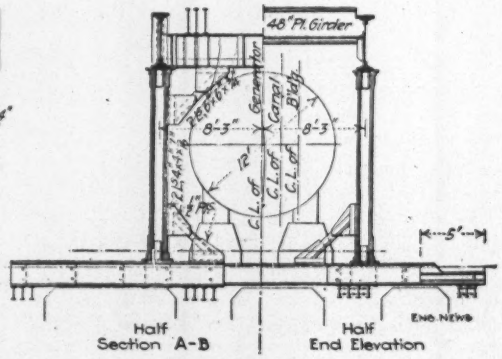


FIG. 1. STEEL SUPPORT FOR 22,000-KW. UNIT AT MARION, N. J.

and in all such instances the braces have the same cross-section as the main bracing, and the space between these brackets and girders is also filled with concrete.

The columns are further braced by means of kneebraces connecting to the grillages, in order to stiffen the joint between the column and grillage. Here also, the space between kneebrace and grillage is filled with concrete. Quite an elaborate grillage system was necessary in order to distribute the load over the walls of the intake and discharge tunnels which were already in place. In order to set the grillage beams low enough the concrete walls of the tunnels had to be cut down 3 ft. Separate grillage tiers are riveted together. The turbo-generator weighs 250 tons.

N. A. Carle is Chief Engineer of the Public Service Electric Co.; C. H. Baker is Mechanical Engineer; and R. von Fabrice, Chief Draftsman.

Edison Electric Illuminating Co., of Brooklyn, N. Y.

A steel foundation for a 22,000-kw. horizontal turbine of the same general design as that at Marion, N. J., has recently been installed in very cramped quarters at the Gold Street generating station of the Edison Electric Illuminating Co., of Brooklyn. Difficulties surrounding the installation of this new turbine were even more severe than were met by the Public Service Electric Co., of New Jersey. In 1911, at the time a 12,000-kw. vertical turbine was installed, it was expected that a similar unit would be required the next year; so subsurface foundations for two adjoining vertical machines were placed. In 1913 it was decided to install a 22,000-kw. horizontal unit. Very small clearances were allowed by the larger machine, and its installation presented unusual difficulties.

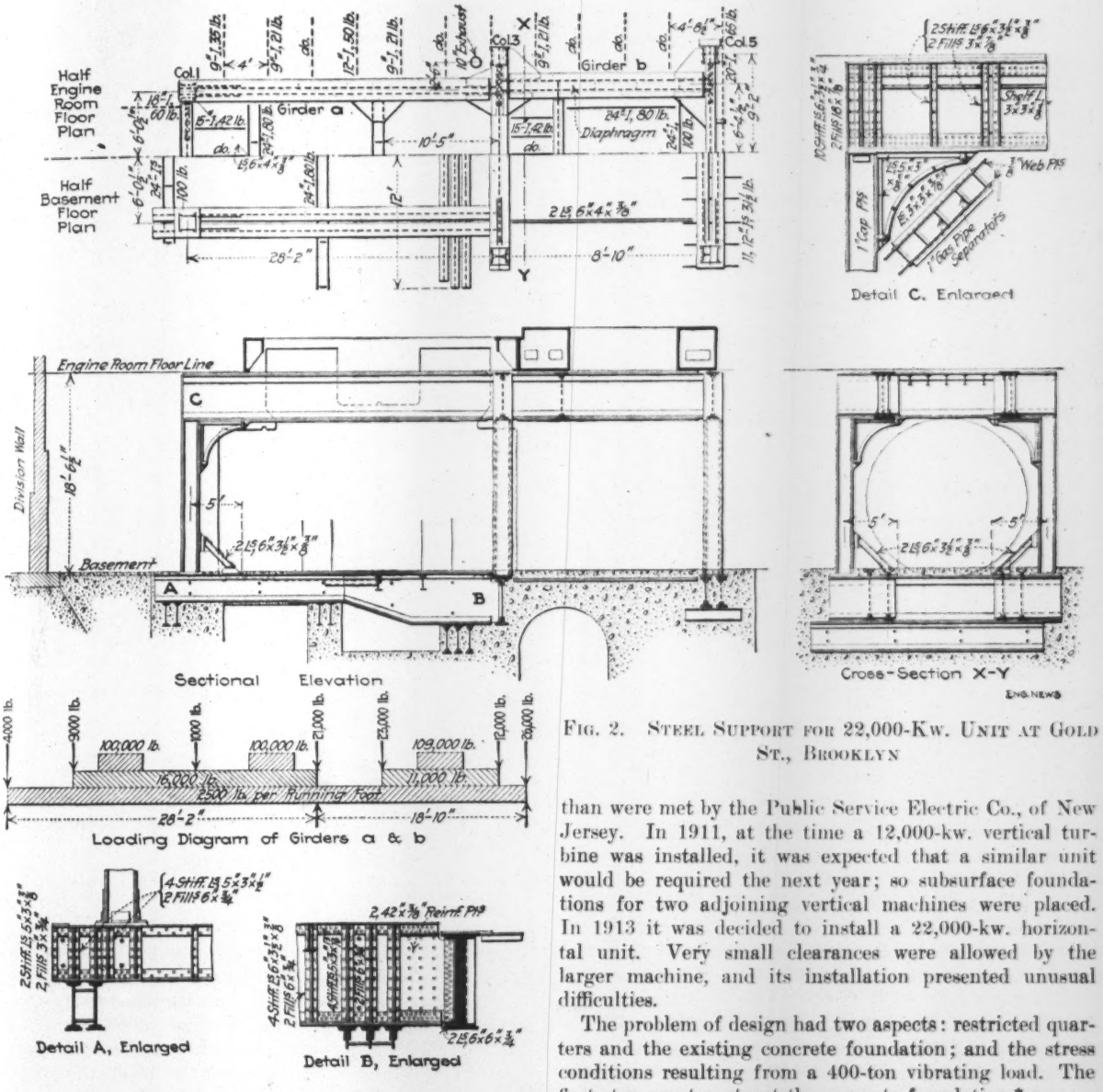


Fig. 2. Steel Support for 22,000-Kw. Unit at Gold St., Brooklyn

The problem of design had two aspects: restricted quarters and the existing concrete foundation; and the stress conditions resulting from a 400-ton vibrating load. The first step was to cut out the concrete foundation.*

Grillage below Basement-Floor Level—The new steel foundation rises from the basement-floor level. The main girders are 48-in.; being as deep as the diameter of the surface condenser underneath and the height to the engine-room floor above will allow. The condenser is 16 ft. 8 in. in diameter, and the headroom between the floors is 18 ft. 6½ in. Under the basement floor are two condensing tunnels, one beneath the other, with concrete

*Described in "Engineering News," Sept. 24, 1913, p. 610.

walls, which serve turbines 4, 5 and 6. About 23 ft. to the left of the upper or discharge tunnel is a new rectangular intake lined on sides and bottom with cast iron, for serving turbines 1, 2 and 3. The top of this new intake is only 3½ ft. below the basement-floor level.

The arch tunnels, built in 1905, were not lined, and as they were not designed to carry any load, the foundation for the new work had to span the tunnel. The heavy load on the center columns was distributed by four 31-ft. cantilever and grillage girders and one transverse, as shown in Fig. 2. This grillage system is shown in detail in the same drawing.

The transverse-grillage girder will be encased in concrete and a 2-in. space left around the sides and bottom. In the bottom space a 2-in. bed of tar will be poured.

and a proportionate value in the other members. The columns and main girders are of standard box-section, filled with concrete so that the different intervals of vibration in the structure would tend toward neutralization and a rigid whole.

The columns are each two 15-in. 45-lb. channels, 30x ½ or $\frac{11}{16}$-in. cover-plates. The main longitudinal girders on the turbine end of the frame are built of two 48x$\frac{9}{16}$-in. plates for web and four 8x8x⅞-in. angles, and two 22x1$\frac{13}{16}$ in. cover-plates.

Between column bases and grillages are 2-in. sole plates through which the connecting rivets pass. Cap plates, 1½ in. thick, are placed between the columns and the main girders, and tend to distribute the load equally.

The outer cover-plates on the columns are continued

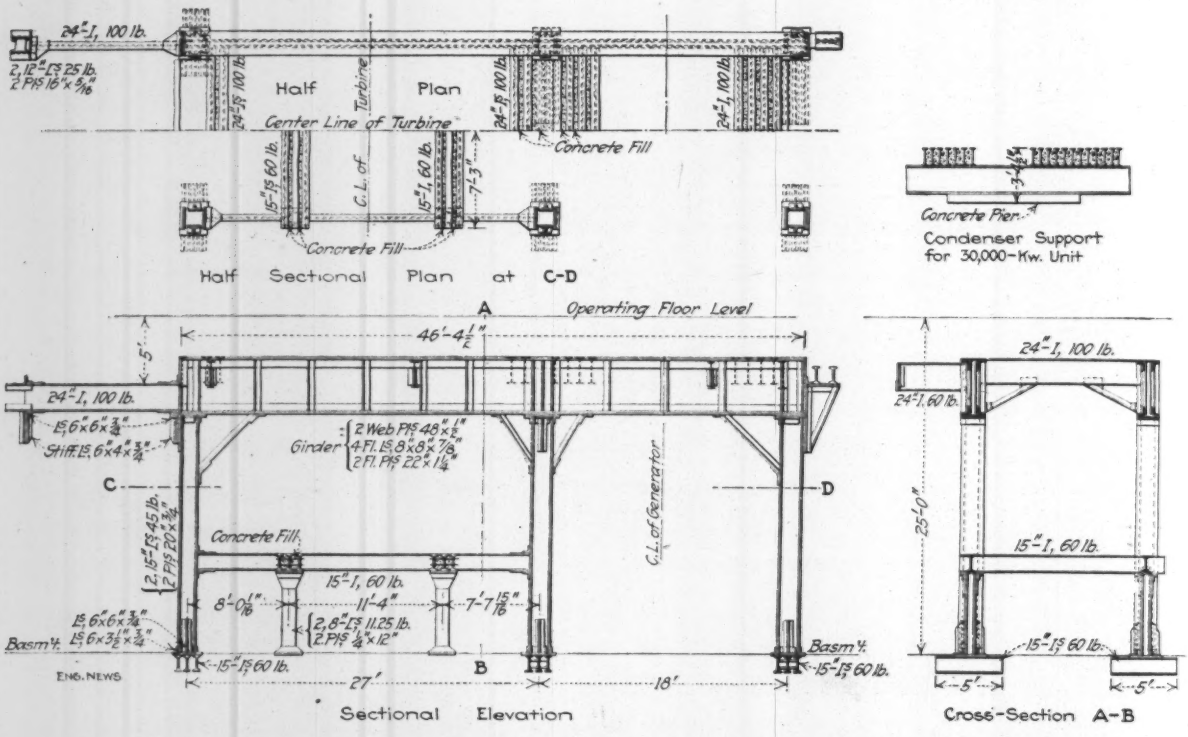


FIG. 3. STEEL SUPPORT FOR 22,000-KW. UNIT AT WATERSIDE NO. 2, NEW YORK CITY

(At upper right is a cross-section of the spring-beam condenser support of the 30,000-kw. unit. With this design of condenser platform the condenser is rigidly connected to the turbine; expansion is taken up by deflection of the system of beams, and, therefore, no expansion joint in the exhaust is necessary.)

After the girder is placed on this bed, sand will be poured in the 2-in. space on the right side. Tar will also be placed under the loaded portion of the cantilever girders. This scheme is intended to cause the load to be shunted away from the old arch and distributed to a heavy cross grillage carried by twenty-three 12-in. diameter concrete-filled steel piles. Where the steel of the grillage is below high-water mark, it will be thoroughly waterproofed. Mean high-water level is 4 ft. 3 in. below the basement floor.

Fresh concrete was placed at the extreme right (Sectional elevation, Fig. 2). In order to give sufficient bearing for the columns, longitudinal grillages were placed across the joint between old and new concrete.

SUPERSTRUCTURE—In order to avoid vibration the stresses in the steel members were figured low: 4000 lb. per sq.in. extreme fiber stress for girders and beams, up past the ends of the girders and riveted thereto. To further insure stiffness, the floor is tied into the steelwork. The webs of the box girders are tied together by a system of diaphragms. Heavy gusset plates are placed at the junction of top members; while the bracing at the foot of the columns takes the form of brackets or knee-braces.

The cast-iron baseplate, which is grouted onto the frame with a 1:2 mix, is assumed to have no stiffness. The girders are designed to carry the weight of the turbine plus that of the floor immediately surrounding it. Actually, the baseplate acts as a continuous cast-iron girder, 36 in. deep. It is formed of six castings bolted together.

The turbine foundation was designed and erected under the direction of G. L. Knight, Designing Engineer, of the Edison Company; F. L. Hough, As-

sistant Engineer. Bernt Berger was Consulting Engineer.

United Electric Light & Power Co., New York City

The 201st. St. generating station of the United Electric Light & Power Co., New York City, is new, completed in 1913, and here was the first opportunity to design steel-turbine foundations without space limitation. Foundations for three 15,000-kw. horizontal turbo-generators were installed in this station last year. Each of the three elements of the foundations consists of two 50-in. girders running parallel to the center line of each turbine, one on each side, supported by six steel columns resting on the building foundation; and a system of beams and girders which frame into each other.

In designing the steelwork a maximum fiber stress of 6000 lb. per sq.in. was used. The structure is riveted throughout; concrete is placed between parallel members. Expansion joints were placed between the two exhaust outlets (turbines are of the double-flow type) of the turbine and the inlet to the condenser, and allowance was made for the extra load imposed by the pressure of the atmosphere when the turbine is running condensing. This pressure amounts approximately to 70 tons.

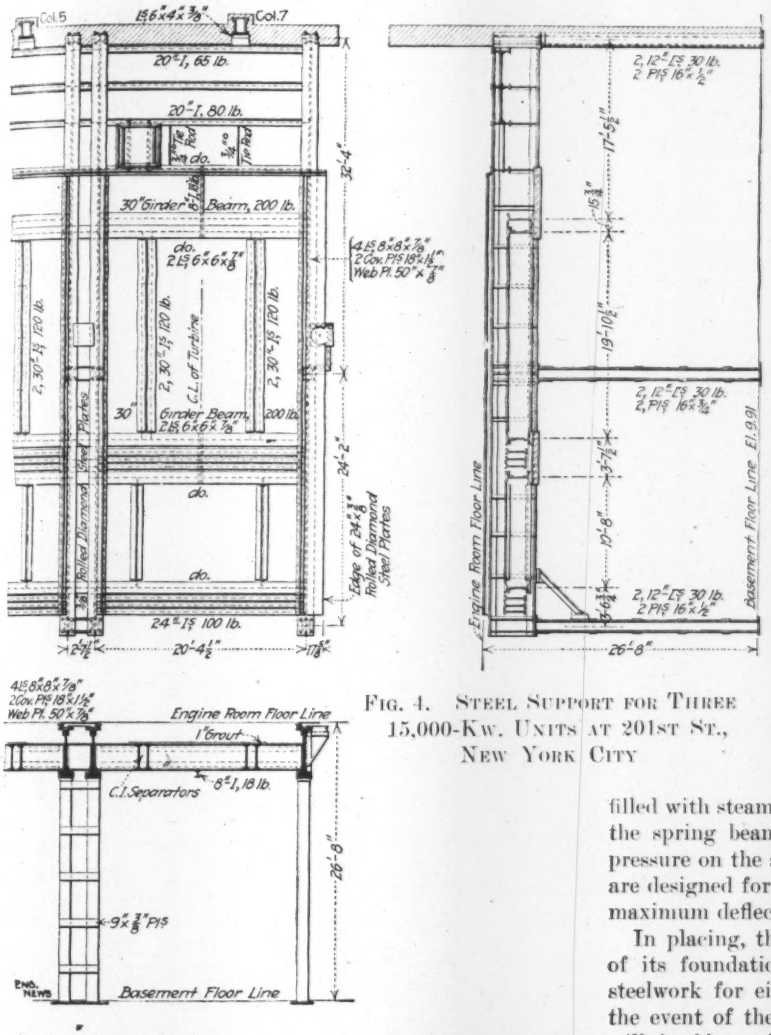


Fig. 4. Steel Support for Three 15,000-Kw. Units at 201st St., New York City

New York Edison Co.

Foundations for 22,000-kw. Unit—The design of the steel foundation for a 22,000-kw. turbo-generator at the Waterside No. 2 generating station of the New York Edison Co., deviated from that at the 201st St. plant, just described, in that instead of transmitting the load from the machine to the main girders through a network of beams and girders, the baseplate rested directly on two continuous 2-web 48-in. girders. The beams and girders framing between the 48-in. girders act principally as bracing for the main system. The six columns consist of 15-in. channels and 20-in. plates. The structure is thoroughly braced. Concrete is placed between parallel members.

Foundations for 30,000-Kw. Unit—The 30,000-kw. turbo-generator at Waterside No. 2 is the largest machine supported on a steel structure. It rests directly on single-web, 60-in. girders, which are strongly braced. Concrete is filled in between the auxiliary and the main girders, to insure stability and rigidity. The eight columns consist of 15-in. channels and 20-in. plates.

In designing the support for the condenser, a system of spring beams (Fig. 3) was used in order to eliminate the customary expansion joint, and thus reduce leakage. The turbine and its condenser will have rigid flange connections. In the rare event of the turbine running noncondensing, the expansion of the condenser shell (being filled with steam instead of containing water) would force the spring beams to deflect, and minimize the upward pressure on the steel superstructure. These spring beams are designed for a fiber stress of 24,000 lb. per sq.in. with maximum deflection.

In placing, the turbine is jacked up to within 1½ in. of its foundation, leaving space between baseplate and steelwork for either a rust joint or concrete grout. In the event of the former being decided upon, iron filings will be blown in by compressed air until the space is filled. In placing concrete grout, expanded metal is first laid on the steelwork to prevent the concrete from disintegrating under continuous vibration.

Personnel—The turbine foundations for the 15,000-kw. turbo-generator at the 201st St. Station, and the 22,000-kw. and 30,000-kw. turbo-generators at Waterside No. 2 Station were designed by Geo. A. Orrok, Mechanical Engineer, and C. B. Grady, Assistant Mechanical Engineer, of the New York Edison Co.

Absence of Fog as Ground for Damages in a stream diversion case was recently brought forward in Pennsylvania in a suit against the Johnstown Water Co. The complainant alleged that the building of a dam by the company so reduced the flow in a stream passing by the complainant's land, that prevalence of fog over the land adjacent to the stream was reduced, and in consequence the crops suffered from frosts from which the fog had previously shielded them.

Comparative Exposure Test of Vehicles for Paint

By Cloyd M. Chapman*

Some four years ago Westinghouse Church Kerr & Co. started to make, in connection with their extensive tests of paints for structural steel, a series of tests of various vehicles then on the market as substitutes for linseed oil and turpentine. These tests were undertaken solely for their own guidance in the specification and use of protective paints for structural steel in their own practice. Since the first series of vehicle tests, a second and much larger series has been made, which has produced some interesting, and it is to be hoped, instructive results. These results are described and presented herewith. It should be borne in mind, however, that the evidence here presented is not to be taken as conclusive proof of the relative value of the various materials; but insofar as it corroborates other evidence, and as it is verified in actual practice, it is useful.

The test was made in the following manner: Some 59 samples of oils, as received from the makers or dealers, were first tested for their drying qualities by placing a few drops of each on a smooth metal plate, and, after exposure to the air at room temperature, noting whether they were dry to the touch after 24 hr. Those that dried were used as received. To a sample of each of the others was added 2% of a turpentine lineoleate drier, and another trial was made on the smooth metal. Any that did not dry within 24 hr. with the 2% of drier had another 2% added. This procedure was continued until the amount of drier required to dry the oil in 24 hr. was determined.

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TABLE OF RESULTS OF WESTINGHOUSE CHURCH KERR & CO. PAINT VEHICLE TESTS

Name of Oil	Supplied by	% of Drier Used	Pigments and Ratings: Red Lead, One Coat, 1 Yr.	Red Lead, One Coat, 2 Yr.	Red Lead, Two Coats, 1 Yr.	Red Lead, Two Coats, 2 Yr.	Iron Oxide, One Coat, 1 Yr.	Iron Oxide, One Coat, 2 Yr.	Iron Oxide, Two Coats, 1 Yr.	Iron Oxide, Two Coats, 2 Yr.	Graphite, One Coat, 1 Yr.	Graphite, One Coat, 2 Yr.	Graphite, Two Coats, 1 Yr.	Graphite, Two Coats, 2 Yr.	Carbon, One Coat, 1 Yr.	Carbon, One Coat, 2 Yr.	Carbon, Two Coats, 1 Yr.	Carbon, Two Coats, 2 Yr.	Average of Ratings of Four Pigments: One Coat, 1 Yr.	One Coat, 2 Yr.	Two Coats, 1 Yr.	Two Coats, 2 Yr.
Cold pressed raw linseed oil	National Lead Company	0–6	100	75	100	90	100	75	100	90	70	30	80	50	65	30	85	85	84	53	91	79
Bleached varnish oil	National Lead Company	0–10	100	85	100	90	90	75	100	85	65	0	80	65	70	55	80	75	81	54	90	79
Extra bleached winter fish oil	N. B. Cook Oil Company	14	100	70	100	80	90	50	100	85	0	0	100	75	90	60	100	85	70	45	100	81
Diamond K Heavy Bodied Pure Linseed Oil	Spencer, Kellogg & Sons	0	100	70	100	80	75	60	100	85	0	0	85	65	80	70	90	80	64	50	94	78
Bleached Winter Fish Oil	N. B. Cook Oil Company	2	85	65	100	75	100	55	100	85	65	0	100	70	75	0	85	80	81	30	96	78
Renewer	Benjamin Moore & Company	0	80	70	100	100	70	60	100	85	45	0	80	75	65	50	100	85	65	45	95	86
Corn Oil	Forest City Paint & Varnish Company	8–12	90	65	100	75	80	60	100	80	0	0	80	70	75	60	100	80	61	46	95	76
Cold pressed linseed oil	National Lead Company	4–5	80	70	85	75	75	65	100	75	60	0	75	65	70	60	75	70	71	49	84	71
Poppy oil	Devoe & Raynolds	4–5	80	70	100	70	80	70	100	80	0	0	75	70	75	60	80	75	59	50	89	74
Perilla oil	Toch Brothers	2	100	75	100	80	70	60	100	75	15	0	70	65	65	55	80	75	62	48	87	74
Acid refined low acid value linseed oil	Spencer, Kellogg & Sons	4–5	75	45	100	75	75	65	80	75	60	0	80	65	70	65	80	70	70	44	85	71
½ raw—½ boiled linseed oil	National Lead Company	0–2	100	65	100	70	75	60	100	80	0	0	80	65	70	30	100	80	61	39	95	74
Soya bean oil	Patton Paint Company	4–8	75	45	100	75	75	65	100	80	0	0	80	65	75	60	100	75	56	43	95	74
Old boiled oil	National Lead Company	0	80	55	100	80	70	60	90	75	50	0	75	65	60	0	80	75	65	29	86	74
No. 2 Thinners	A. Wilhelm Company	4–8	100	75	100	80	80	45	85	75	0	0	80	60	65	50	90	75	61	43	89	73
Acid refined high acid value linseed oil	Spencer, Kellogg & Sons	4–5	80	65	100	75	80	70	80	75	60	0	75	45	65	50	80	Lost	71	46	84	64
Light pressed fish oil	N. B. Cook Oil Company	2	55	45	80	70	100	60	100	75	60	0	90	70	75	0	100	75	73	26	93	73
Delhi oil	Benjamin Moore & Company	0–10	90	80	100	75	80	65	90	75	30	0	80	60	65	0	85	80	66	36	89	73
Corn oil	Toch Brothers	8	80	55	100	70	80	65	100	80	0	0	80	60	75	55	80	75	59	44	90	71
Pure raw linseed oil	Spencer, Kellogg & Sons	4–6	80	70	100	75	80	65	85	75	15	0	80	60	65	55	80	70	60	48	86	70
Raw linseed oil	National Lead Company	4	80	70	100	80	80	70	90	75	0	0	75	30	75	60	80	75	59	50	86	65
Raw fish oil	Toch Brothers	18	80	65	100	75	80	15	100	70	60	0	85	70	65	0	85	75	71	20	93	73
Raw linseed oil, ½—Flexol, ½	Spencer, Kellogg & Sons—Flexol Company	0	80	75	100	85	70	55	100	80	15	0	75	60	55	0	80	70	55	33	89	73
Brown pressed fish oil	N. B. Cook Oil Company	14	70	55	100	65	100	30	100	75	0	0	80	65	80	15	100	70	63	25	95	69
Boiled fish oil	Toch Brothers	2	85	70	100	75	70	0	90	80	65	0	80	70	70	0	80	75	72	18	87	75
½ raw—½ boiled linseed	National Lead Company	0	75	75	100	80	75	30	100	80	0	0	80	70	65	0	100	75	54	26	95	76
Vaco oil	Benjamin Moore & Company	0	65	70	100	80	75	65	80	80	0	0	70	50	65	15	80	70	51	43	83	71
Clear iron enamel (linseed oil)	Sterling Varnish Company	0	70	65	100	70	70	55	100	80	0	0	80	70	70	55	85	75	53	44	91	76
Soya bean oil	A. M. Parks	4–8	65	65	80	80	80	75	100	85	0	0	80	70	65	0	80	75	53	35	85	78
Special boiled linseed oil	Spencer, Kellogg & Sons	0	75	60	85	75	70	55	80	70	60	0	80	65	65	30	80	70	68	49	81	70
China wood oil	Nubian Paint & Varnish Company	7½	75	65	90	80	70	65	100	80	0	0	80	65	65	0	80	65	53	33	88	73
Heavy bodied boiled linseed oil	Spencer, Kellogg & Sons	0	85	70	100	80	75	60	80	75	0	0	80	60	65	0	80	70	56	33	85	71
Raw fish oil	Toch Brothers	2	70	65	70	65	80	0	100	80	60	0	85	70	65	0	80	80	69	16	84	74
Durable lac oil	C. H. Hoyt	0	70	65	100	80	70	60	100	80	0	0	70	60	65	15	80	70	51	35	87	73
China wood oil	A. M. Parks	2–4	80	70	100	80	70	50	100	75	15	0	80	75	0	0	85	75	41	30	91	76
China wood oil	Patton Paint Company	0–2	80	70	100	85	65	45	80	80	0	0	85	70	15	0	90	75	40	29	89	78
Treated boiled linseed oil	Patton Paint Company	4	100	65	100	Lost	80	65	100	70	0	0	75	55	65	Lost	90	70	61	33	91	49
Raw refined linseed oil light body	Sterling Varnish Company	7½	80	70	80	70	70	15	100	80	0	0	75	55	70	0	90	70	55	21	86	69
Oil substitute No. 1631	J. Lucas & Company	2	100	65	100	80	70	60	80	75	0	0	70	15	55	0	80	70	56	31	82	60
Caustic refined neutral acid value	Spencer, Kellogg & Sons	2	45	0	80	70	70	60	80	70	30	0	80	70	65	45	80	70	53	26	80	70
A. X. L. oil	Benjamin Moore & Company	2	70	65	100	85	70	45	100	75	0	0	70	45	15	0	100	70	39	28	92	69
Oil substitute No. 1630-R	J. Lucas & Company	0	85	70	100	80	80	45	85	80	0	0	65	30	0	0	100	75	41	29	88	66
Oil substitute No. 1629-R	J. Lucas & Company	0	80	65	100	75	65	30	80	75	0	0	65	30	65	0	80	75	53	24	81	64
Amazon Japan oil	Forest City Paint & Varnish Company	0	80	70	85	75	80	65	100	75	0	0	60	0	15	0	85	70	44	34	83	55
Old raw linseed oil	National Lead Company	6	85	65	100	70	70	45	80	75	0	0	65	0	55	0	80	70	53	28	81	54
Japan oil No. 2	J. B. Sipe & Company	0	55	30	80	75	70	65	90	70	0	0	75	65	0	0	75	65	31	24	80	69
Chian wood oil	Nubian Paint & Varnish Company	2	60	60	80	75	65	0	90	70	0	0	80	70	0	0	85	80	31	15	84	74
No. 1 oil	Benjamin Moore & Company	0–2½	...	...	...	...	65	0	85	75	0	0	100	70	60	0	80	75	42	0	88	73
Boiled fish oil	Toch Brothers	0–6	0	0	80	70	80	60	100	75	0	0	60	15	60	0	100	75	35	15	85	59
Protectus "S" linseed oil substitute	Protectus Paint Company	0	75	65	100	80	80	0	100	75	0	0	60	0	0	0	85	65	39	16	86	55
Raw linseed oil, ½—flexible compound, ½	Spencer, Kellogg & Sons - Flexible Compound Co.	0	80	65	80	70	65	0	80	75	0	0	70	45	0	0	80	70	36	16	78	65
No. 1 Thinners	A. Wilhelm Company	4	80	75	100	80	60	0	90	65	0	0	60	0	15	0	80	70	39	19	82	54
Japan oil No. 1	J. B. Sipe & Company	0	45	0	65	60	65	55	80	75	0	0	65	45	55	0	70	60	41	14	70	60
Japinal	Columbia Renfiing Company	0	60	15	80	70	55	0	100	75	0	0	65	60	0	0	80	65	29	4	81	68
Special vehicle, cotton oil pitch	Southern Cotton oil company	0	55	45	70	65	65	0	80	70	0	0	65	0	65	0	80	60	46	11	74	49
Linseedol	Rubberoline Manufacturing Company	0	0	0	65	45	45	0	100	70	0	0	0	0	0	0	65	Lost	11	0	58	38
First run resin oil	American Naval Stores Company	4	0	0	65	45	0	0	80	60	0	0	0	0	0	0	30	0	0	0	44	26
Prepared resin oil	American Naval Stores Company	0	15	0	80	55	0	0	0	0	0	0	0	0	0	0	15	0	4	0	24	14
Pine oil	American Naval Stores Company	0	0	0	0	0	0	0	70	55	0	0	0	0	0	0	0	0	0	0	18	14
	Average—1 coat, 1 year		72.1				71.1				15.3				51.3							
	Average—1 coat, 2 years			58.3				43.9				0.5				19.0						
	Average—2 coats, 1 year				91.0				89.7				71.4				81.4					
	Average—2 coats, 2 years					73.6				75.0				50.4				69.4				

The amount of drier used with different pigments varied considerably. The red-lead paints required much less drier than the carbon mixtures. The iron oxide and the graphite had little effect upon the drying time of the oil. The percentage of dryer required varied from zero to 18%.

Samples of four pigments commonly used in structural-steel paints, viz., red lead, iron oxide, graphite and carbon, were obtained from the manufacturers. The red lead was of the grade known as Painters' Red Lead and analyzed 96.92% true red lead, Pb_3O_4, the remainder being litharge, Pb_2O_3. The iron oxide was of a well known brand of American ore which has been on the market for many years. It analyzed 49.32% Fe_2O_3 and 45.6% insoluble. The graphite was of the artificial variety of the grade designated as "Aa 1." The makers state that "it is guaranteed to contain at least 90% pure graphitic carbon, and the ash content is only that which is in combination with the carbon, chiefly carbide of calcium." The carbon was a natural-gas carbon black containing about 98% carbon, 0.1% oily matter, 0.1% ash and about 2% moisture.

These pigments were ground to a stiff paste, in pure aged, raw linseed oil. Each of these pastes was then thinned with each of the oils under test, with dryer added, to a normal, smooth-working paint consistency. These paints were each spread on two 2x6-in. mild-steel plates, No. 16 gage, of about the following analysis: Carbon, 0.06%; phosphorus, 0.095%; manganese, 0.38%. These plates had previously been numbered for identification and prepared by pickling in hot dilute sulphuric acid to remove the mill scale, the acid neutralized with soda, washed and packed in powdered lime until used, as recommended by Committee E (now known as Committee D-1), of the American Society for Testing Materials in their report for 1905.

One of these plates was given one full even coat, and the other was given two such coats with an interval of five days for drying between coats. All work was done by one operator experienced in such work, and care was taken that each paint was mixed to as nearly as could be judged the same consistency, and that each paint was applied to the same thickness and evenness of coat to the plates. When dry the plates were fastened to boards with galvanized nails and exposed to the weather on the roof of the Maritime Building at the southern extremity of Manhattan. The boards holding the plates were supported on racks in such a position that the plates were inclined 45° from the horizontal and facing south.

Examinations were made every three months of the condition of each plate, and a record was made to an arbitrary scale of 100 to indicate the condition at each examination. In the scale of ratings, 100 indicates that no rusting of the metal has become apparent to the eye; 90 indicates a slight rusting such as one small spot or pinhead. A few such spots of rust, say three or four, reduce the rating to 85. An aggregate area of rust spots equivalent to ¼ sq.in. makes the rating 80; an area of ½ sq.in. to 75; 1 sq.in., 70; 2 sq.in., 65; and so on down the scale until zero indicates that the entire exposed surface of the plate is rusted.

The accompanying table gives the ratings of all specimens at the end of one year and two years. The headings of the first and second columns are self-explanatory. In the third column is given the per cent. of dryer added to each vehicle. This per cent. varies in many cases, as noted above, and the lower and upper figures only are given in this column. In the next 16 columns are given the ratings of each test plate at the end of one and two years for both the one-coat and two-coat specimens. The last four columns give the average of the ratings of each oil with all four pigments for the one-coat and two-coat specimens at the end of one year and two years.

A comparison of the averages in these last four columns will indicate the relative value of the various oils as paint vehicles, as developed in these tests.

It is the purpose of this article to describe a series of tests and to present the results obtained and not to make comparisons that may not be warranted by the facts. There is, however, one comparison which there is an opportunity to make in connection with these tests and that is as the relative efficiency of the four samples of pigments used. At the foot of the table there are averaged the ratings of the one- and two-coat specimens at the end of one and two years for each pigment. A comparison of these averages will indicate the relative value of the four pigments used in these tests.

Another noticeable feature of these and other tests made by this company is the fact that some paints show high efficiency for short periods which fail completely upon longer exposure. This seems to be particularly true of one-coat tests and it makes it difficult or dangerous to judge the value of a paint for long-time protection on its short-time record. On the other hand, there are a few cases of steel painting in which only short-time protection is desired and in those cases these paints which possess high efficiency for a short time may be useful.

The Engineer

(With apologies to Kipling)

By ROBERT T. GEBLER*

You can rave about yer bloomin' Tommy Atkins on parade
And yer lady-like lieutenants on the Mall.
You can talk about your gunboats, yer rifles and yer camps
And yer heroes in the rain of leaden ball.
But the bloke I doffs me hat to
Didn't fight the sly mulatto
But he was in the battle just the same.
He's the bloke that planned yer bridges,
Built yer roads across the ridges,
To let Tommy Atkins march into the game.

With 'is transit or 'is level he would work to beat the [devil—
The devil of a Kaffir, sir, I mean—
But the blokes as write the stories never pass 'im any glory
And they never throws 'im on the movie screen.
Out there 'e is a plannin'
And a river 'es a spannin'
As 'e gets the place in order fer the fair;
But the 'eathen start a shoutin;
They've fergotten all about 'im
And the history won't say that he was there!

Yer millionaires cut capers, get their pictures in the papers
And the public then begins a bloomin 'owl
'Bout the aqueducks 'en highways, the railroads and the [byways
An' big jobs like the Panama Canal.
But as I've often read it—
The bloke who gets the credit
Is not the dusty khaki'd engineer;
But the guys wot 'ave the shillins
Get in first on all the killins',
Of the lad who turned the trick we never 'ear.

So I think when I am ridin down to Dover, or a glidin
In a taxi 'cross the bridge in Lunnon town,
Of the lads who built the town, sir, and the sewers under
The sea wall and Suez and did 'em brown. [groun' sir.
But they never sings 'is praise, sir
In the papers nowadays, sir;
'E never gets the credit that's 'is due.
But the fellers with the money
Wouldn't get the praise and honey
If the engineers wern't there to pull 'em through.

*The Technical Supply Co., Scranton, Penn.

The Inverted Weir

By E. W. Rettger*

In connection with the discussion of proportional-flow weirs by the writer, Prof. O. H. Stout, and E. A. Pratt, in recent numbers of Engineering News, it may be of interest to call attention to the proportional-flow *inverted weirs* and incidentally to inverted weirs in general.

If any one of our standard weirs be inverted and what corresponded to the crest be now taken as the water surface (fixed) and what corresponded to the water surface be now taken as the crest (movable), we have an inverted weir; that is, the height h is changed by raising or lowering the crest and keeping the water surface fixed. Naturally the inverted weirs do not have as wide application as the standard weirs. Under certain circumstances they can be used to advantage. Inverted weirs are in use, but (so far as the writer is aware) the proportional-flow inverted weir is here given for the first time.

If, in Fig. 1, $z = \dfrac{b}{2\sqrt{x}}$, where b is the width of weir at unit distance from crest ZZ, and z is the half width of a narrow strip at distance x from OZ, we have the proportional-flow weir discussed by Prof. Stout (Eng. News, Vol. 72, p. 148) and the writer (Vol. 71, p. 1409). The theoretical flow of this weir was found to be

$$Q_1 = 2\sqrt{2g}\int_o^h \frac{\sqrt{h-x}}{2\sqrt{x}} \cdot b \cdot dx = \sqrt{2g} \cdot \frac{\pi b}{2} \cdot h$$

Now invert this weir as shown (Fig. 2) and let ZZ be the water surface (fixed) and K the crest (movable). The theoretical flow through this weir is

$$Q_2 = 2\sqrt{2g}\int_o^h \sqrt{x} \cdot \frac{b}{2\sqrt{x}} \cdot dx = \sqrt{2g} \cdot \frac{bh}{2}$$

This second weir is also a proportional-flow weir. However, its coefficient is different from that of Fig. 1.

Let us now consider the general case where $z = \dfrac{bx^n}{2}$. Here b is the width of the weir at unit distance from crest and z is *half* width at distance x from crest. If $n = -\frac{1}{2}$, that is, if $z = \dfrac{b}{2\sqrt{x}}$, we have the proportional-flow weir discussed above. If $n = 0$, that is, if $z = \dfrac{b}{2}$, we have the rectangular weir. If $n = 1$, that is, if $z = \dfrac{bx}{2}$, we have the triangular notch. The theoretical flow through this general weir is

$$Q_1 = 2\sqrt{2g}\int_o^h \sqrt{h-x} \cdot z \cdot dx$$

$$= \sqrt{2g} \cdot b \cdot \int^h \sqrt{h-x} \cdot x^n \cdot dx$$

If, now, n is a multiple of $\frac{1}{2}$, then the integral $\int_o^h \sqrt{h-x} \cdot x^n \cdot dx$ can be evaluated by means of a table of standard integrals. For any value of n greater than -1, and especially for the case when n is not a multiple of $\frac{1}{2}$, we may expand $(h-x)^{\frac{1}{2}}$, that is,

$$(h-x)^{\frac{1}{2}} = h^{\frac{1}{2}} - \tfrac{1}{2}h^{-\frac{1}{2}}x + \tfrac{1}{8}h^{-\frac{3}{2}}x^2 - \tfrac{1}{16}h^{-\frac{5}{2}}x^3 + \ldots$$

multiply each term by x^n and integrate between 0 and h. Each term will then be found to contain $h^{n+\frac{1}{2}}$. The theoretical flow through this weir is, therefore, proportional to $h^{n+\frac{1}{2}}$. Now invert this weir as explained, that is, what was formerly water surface is now to be the crest (movable) and what was formerly the crest is now to be the water surface (fixed). The theoretical flow through this inverted weir is

$$Q_2 = 2\sqrt{2g}\int_o^h \sqrt{x} \cdot \frac{bx^n}{2} \cdot dx = \sqrt{2g} \cdot \frac{2b}{2n+3} \cdot h^{n+\frac{3}{2}}$$

We thus see that the flow through this inverted weir is also proportional to $h^{n+\frac{1}{2}}$. Or, in general, if any weir for which $z = \dfrac{bx^n}{2}$ be inverted, as explained above, the flow through the inverted weir is proportional to the same power of h.

By giving n the proper value (provided n is greater than -1), the flow through the weir (and therefore through the inverted weir) can be made proportional to any power of h desired.

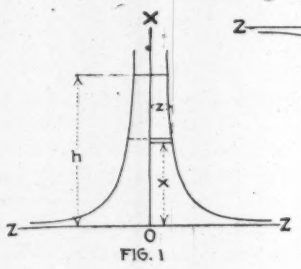

FIG. 1

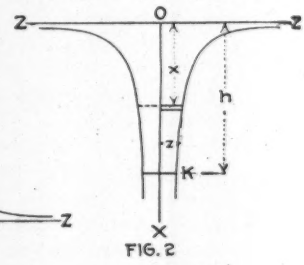

FIG. 2

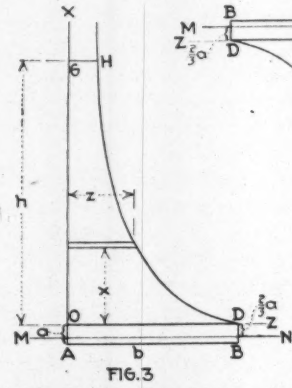

FIG. 3

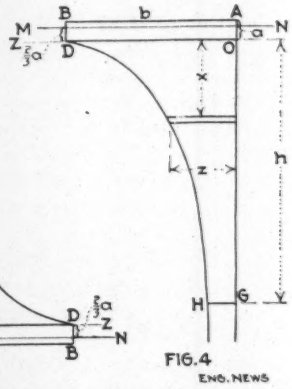

FIG. 4

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The foregoing weirs may be called simple weirs, in distinction from such weirs as the Sutro Weir, described by Mr. Pratt (Vol. 72, p. 462). This weir (Fig. 3) consists of a rectangle $AODB$ of height a and width b and then a part $OGHD$ bounded by the curve DH. This curve DH is so determined that the theoretical flow through the weir is

$$Q_3 = \sqrt{2g} \cdot b\sqrt{a}\,(h + \tfrac{2}{3}a)$$

That is, the weir is a proportional-flow weir with reference to a line MN, located $\frac{2}{3}a$ from OZ. The water level evidently must not fall below OZ. The equation of DH with reference to the line OZ is derived by Mr. Pratt as

$$z = b\left(1 - \frac{2}{\pi}\tan^{-1}\sqrt{\frac{x}{a}}\right)$$

Since the Sutro weir consists of two parts, the rectangular part and the curved part, we can hardly expect that the inverted weir will also be a proportional-flow

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weir. By a slight modification, however, it can be made a proportional-flow weir. Let AB now be the water surface (fixed) and GH the crest (movable). See Fig. 4. Let us so determine the curve DH that the flow through this weir is also

$$Q_4 = \sqrt{2g}\, b \sqrt{a}\, (h + \tfrac{2}{3}a)$$

The flow will consist of two parts, that through the rectangle and that through the curved part:

$$Q_4 = \tfrac{2}{3}\sqrt{2g} \cdot b \cdot a^{\frac{3}{2}} + \sqrt{2g}\int_0^h \sqrt{a+x} \cdot z \cdot dx$$

Equating the two values of Q_4 and simplifying, we have

$$\int_0^h \sqrt{a+x} \cdot z \cdot dx = b\sqrt{ah}$$

This equation will be satisfied if $z = \dfrac{b\sqrt{a}}{\sqrt{a+x}}$. The inverted weir then will be a proportional-flow weir with reference to the line MN, if

$$z = \frac{b\sqrt{a}}{\sqrt{a+x}}$$

The Cippoletti weir, like the Sutro weir, is not a simple weir. It is a combination of the triangular-notch and the rectangular weir. It is easily shown that the inverted weir will be a weir of the same nature if the base of the equivalent triangular inverted notch is equal to $\frac{1}{4}h$ instead of $\frac{1}{2}h$, as is the case with the triangular notch in Cippoletti's weir itself.

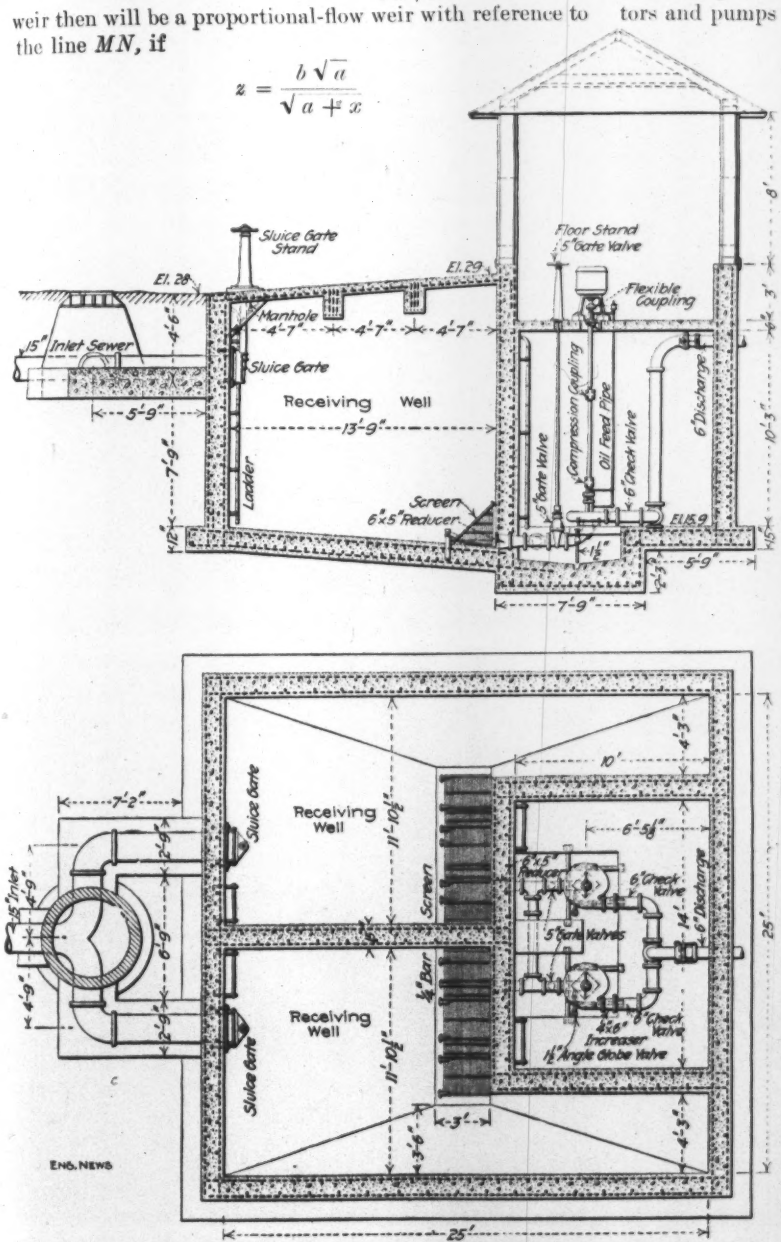
An Electric Sewage-Pumping Station, Audubon, N. J.

In laying out the sewers at Audubon, N. J., it was found necessary to lift the sewage from one drainage area to a high-level gravity sewer. The accompanying drawings show the general arrangement of the sumps, screens, motors and pumps found advisable.

There are two centrifugal pumps with 5-in. suction and 4-in. delivery openings. The pumps are especially designed for handling sewage and to pass solids up to 1 cu.in. They have single-suction castings, on lower side, flared for easy entrance and carrying water directly to the impeller. Each pump has a capacity for 200 gal. per min. against a head of 50 ft., including friction, when operating at a speed of 1200 r.p.m. The volute is cast iron, one piece with openings in the sides slightly larger than the impeller to permit easy removal of the latter. The impellers are of cast bronze of the open type with vanes and web to hub. The shaft is of Tobin bronze extended through the pump bearing, fitted with a rigid coupling, and a stuffing-box at the top of the pump bearing. The shafts are directly connected through flexible couplings to vertical 10-hp. motors. The specifications called for an efficiency of 52% for the combined unit.

The intake well is divided into two parts and the pumps may draw from either or both sections at the same time. The two pumps discharge into a 6-in. cast-iron force main which enters the gravity sewer at a distance of 800 ft.

The plans were made by J. J. Albertson, Borough Engineer, with Geo. L. Robinson and E. L. Wagner (New York Sewage Disposal Co.), of New York City, Consulting Engineers.



PLAN AND SECTIONAL ELEVATION OF ELECTRIC SEWAGE-PUMPING STATION, AT AUDUBON, N. J.

The Longest Railway Tunnel in India is that piercing the Khojak Range between Quetta and Chaman, near the northwestern frontier, which has a length of 12,870 ft. The second longest tunnel, 3900 ft., is now being driven on a double-track cutoff between Thana and Diva. This pierces the Parsik Hill and reduces the distance 11 miles as compared with the present line, which makes a detour around the hill. The new line will be used for through traffic.

Field and Office

Resurfacing Asphalt Pavements in San Francisco, Calif.

By James Owens*

In San Francisco there is a greater mileage of asphalt and bituminous rock pavements than of any other kind. With a large mileage of asphalt pavements growing old there is an ever-pressing need of repair. It was not till January, 1913, however, that the subject of resurfacing such pavements was taken up in earnest.

Fig. 1. Asphalt Resurfacing Gang at Work, San Francisco, Calif.

An expeditious and economical method of satisfactorily resurfacing pavements has been developed. Since Jan. 17, 1913, four Lutz asphalt-resurfacing machines have been leased by the city. Three of these machines have been almost constantly engaged on resurfacing work.

*Assistant Engineer-in-Charge of pavement design, City Engineer's office, San Francisco, Calif.

In the main, the work performed by these resurfacing machines has been very satisfactory. During the fiscal year ending June 30, 1914, 171 city blocks were resurfaced. This is equivalent to 296,600 sq.yd. of asphalt surface. The cost of the work, including repairs, royalties, etc., has amounted to 5⅓c. per sq.yd.

The leased price of each machine is $1800 with the understanding that a minimum amount of repair work of 10,000 sq.yd. per year must be performed. This amounts to $500 yearly.

The average force required to operate each machine is: 1 foreman, 1 engineer, 14 laborers.

Two machines working together, as shown in Fig. 2, require 1 foreman, 3 engineers and 18 laborers. The average amount of pavement resurfaced per day for the entire year amounts to 1144 sq.yd.

The hood of each resurfacing machine has a heating surface of 6⅔ sq.yd. The heat of an oil flame is transmitted to the hood by means of a baffle wall and is evenly distributed over the area to be surfaced by means of plates in the hood. The hood is dropped to the surface of the street and old pavement given a slow heating. This softens the asphalt so that the surface can be made uniformly rough by means of hoes, especially cut for that purpose.

The dead material is raked off and a thin layer of new asphalt wearing surface is then spread and raked over the heated surface and immediately rolled with a 5-ton steam-roller. By this method the bond between the old and the new surface is perfect. Numerous tests on samples of pavement treated thus have failed to show where the two surfaces come together.

The speed with which a street paved with asphalt can

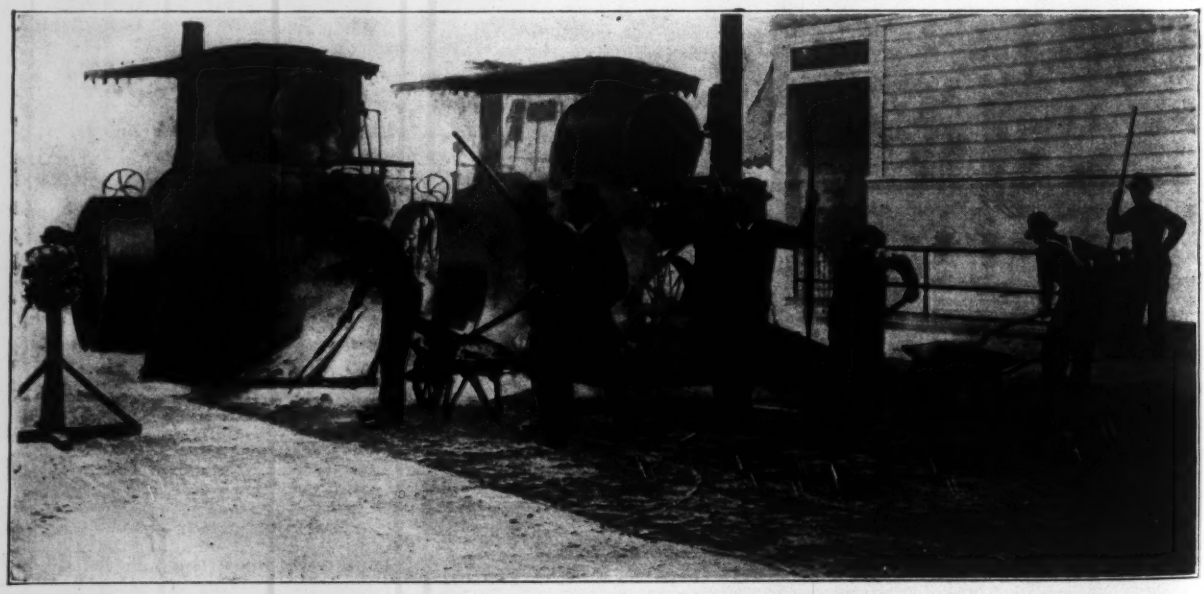


Fig. 2. Two Lutz Asphalt Surface Heaters Working Together, San Francisco, Calif.

be resurfaced is of great importance in the business section of the city. Many of the streets have been resurfaced in this way and the work of these machines has been done quickly and quite satisfactorily. One of the largest single jobs of resurfacing was that of Market St. from the Embarcadero to 13th St.

Concrete Aggregate in Kansas City: Careful Inspection Necessary

A Kansas City engineer, in close touch with the local building situation, sends a strong memorandum on the subject of keeping track of the quality of sand and stone for concrete. With building prospects in bright condition, and with the modern wide use of either concrete-incased steelwork or reinforced-concrete construction, the importance of giving close attention to the quality of sand and stone is worth special emphasis at the present time.

Concrete for building purposes is either a very high-grade building material or the poorest; poor materials are virtually sure to place it in the latter class.

Soft Limestone a Source of Trouble

In the neighborhood of Kansas City are excellent quarries, furnishing a good grade of blue limestone. This, in its properly screened condition, contains little stone dust and no clay. Other quarries, however, work the overlying or surface layer; this is a soft, coarse stone, containing a large proportion of clay dust, in some specific instances as high as 16%. With such material in the market, specifications are no protection unless the engineer in the field sees that the specifications are adhered to.

Kaw River Sand

The quality of stone is ordinarily under fairly good supervision because of the large size and uniformity of the material. Sand, on the other hand, more frequently gives unexpected trouble. In Kansas City the sand question needs to be watched considerably more than the stone question, on account of the varying river conditions. There are several sand companies operating in the Kaw River, some of which claim to furnish washed sand. It is a notable fact that tests advertised by these companies show up wonderfully well, but do not compare favorably with the tests taken at random either from the bins or from the sand delivered on the job. The reason is probably that the tests were made at a time when the sand was running good, whereas the average output may be of much lower grade.

The Kaw River carries 80% of its total yearly volume of solids during the high-water months of May and June. Immediately after this period a very good grade of sand can be obtained from the river, provided it is washed; but between the months of October and May—just when weather conditions have the greatest influence on concrete work—the river sand is of poor quality, containing lumps of clay, mud balls, and a large percentage of silt. This sand should be subjected to rigorous tests before being allowed to be used in concrete structures.

Another factor in the sand situation is the presence of a number of industrial plants along the Kaw between Turner and the mouth: an acid plant, soap factories, and innumerable packing houses, whose sewage contains much grease and oil, which may have a very injurious effect on the quality of the sand.

Local engineers and architects have begun to discuss this question of sand and stone. It is expected that from this discussion some action will result to improve conditions and thus reduce the chance of accident in concrete building work. The suggestion has been made that a city ordinance should require special tests or other precautions concerning sand during the winter period.

Shipping a Long Bridge Girder

The curious "alligator" girder shown in the accompanying cut is one of the main girders for a deck-span bascule bridge of the Strauss type. The main trunnion is shown next to the side brace at the left and the smaller trunnion at the extreme end is for the counterweight system. The girder is 129 ft. 4 in. long and 12 ft. 1 in. deep, and weighs 55 tons. It was shipped on three steel flat-cars, being supported on each end car by a bolster with side braces, and supported on the middle car by a bolster with sliding contact surfaces to allow free movement of the car in passing curves.

A 129-Ft. 55-Ton Girder for a Bascule Bridge

The bridge is at Houston, Tex., on the International & Great Northern Ry.; O. H. Crittenden, Chief Engineer. It is being built by the Wisconsin Bridge & Iron Co., of Milwaukee, Wis.

Compulsory Inspection of Engine Flywheels—Many states and municipalities have enacted laws for the compulsory inspection of steam boilers. Insurance companies claim that the percentage of flywheels that burst is greater than the percentage of steam boilers that explode. In view of this condition, the "Monthly Bulletin" of the Fidelity & Casualty Co., of New York asks for laws compelling the inspection of engine flywheels, and goes on to say that

such laws, of course, would provide not only for the inspection of flywheels, but also for the inspection of the engines driving them and particularly the governing mechanism of those engines. Flywheels themselves are not often defective, but some accident to or derangement of the governing mechanism of the engine allows it to race and burst its flywheel by centrifugal force.

A Dragline Excavator with Wagon Loader

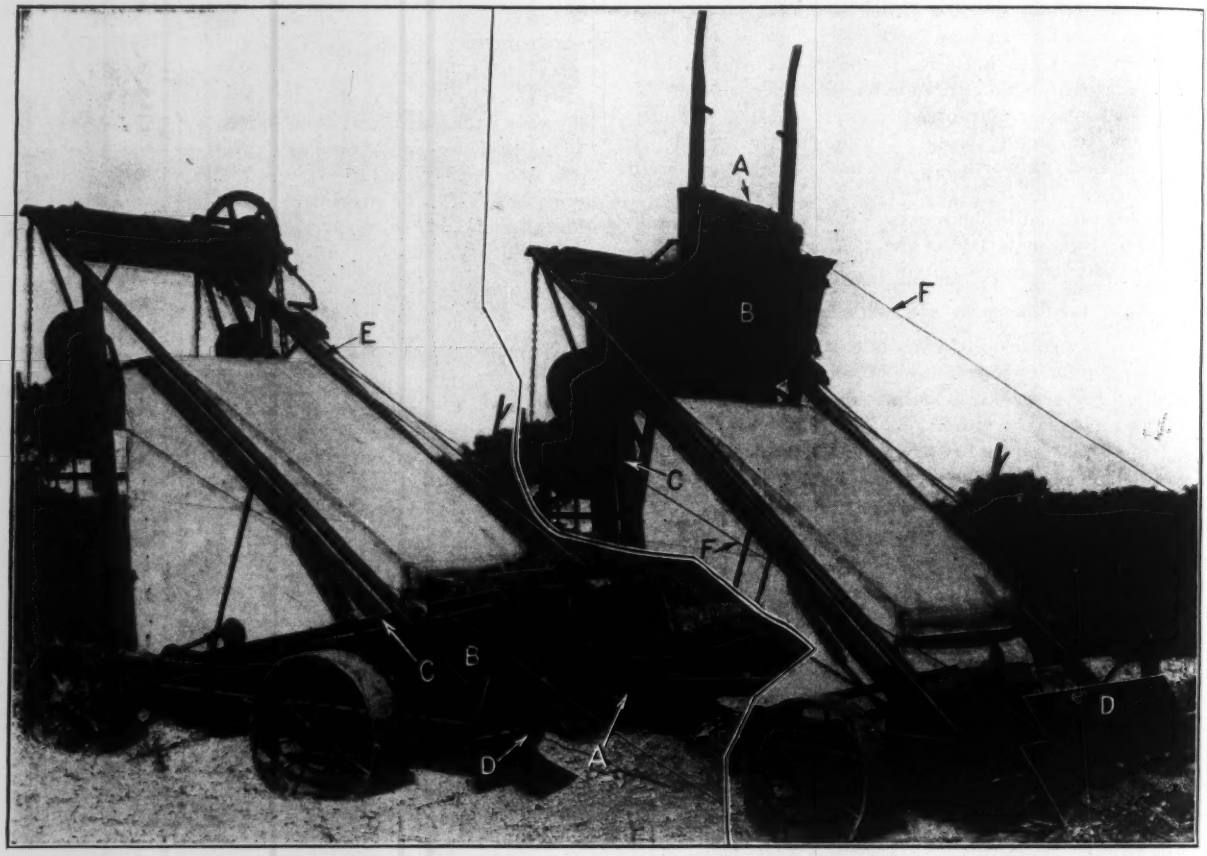
A dragline excavator with a loader for dumping the material into wagons is a recent development in excavating machinery. A machine of this type built by the Albrecht Excavator Co., of Milwaukee, Wis., is shown in the accompanying two views.

The loader is mounted on wide-tired wheels and has a pair of triangular side frames, whose ends project as cantilevers on the loading side of the machine. These projecting ends also carry the drum for the hauling cable attached to the bail of the bucket or slip scraper. At one side of the machine is another drum for the backhaul cable, which is led to snatch-blocks in the excavation and then back to its attachment to the rear end of the bucket. Pivoted to the forward ends of the sills are two arms which carry a dumping hopper; in its lowered position this lies at the rear end of the side frames, with its edge resting on a steel apron. The drums are operated by a 10-hp. gasoline engine, mounted separately, but the loader is moved from place to place by a team.

A man in the pit holds the scraper in position to take its load as it is started by the cable, and the loaded scraper is then hauled to the top of the slope, where the apron guides it into the hopper. A lock on the hopper is released automatically, and the continued pull on the cable swings the hopper through a vertical arc, until at the end of the travel the scraper within it is in a vertical position, discharging its contents into a wagon standing beside the loader.

The backhaul cable then returns the hopper to its lowered position and pulls the scraper back to the loading place in the pit. At the bottom a chain 20 to 40 ft. long is stretched at right angles to the cable and anchored to stakes or deadmen. A pulley is attached near one end of the chain and a second pulley can be attached at any point along the chain. The backhaul cable is led first through the fixed pulley and then through the movable pulley before returning to the scraper. Thus by shifting the latter pulley along the chain the scraper can cover the triangular area having the chain as its base and the loader as its apex.

To prevent the apron from being clogged with material dropped from the scraper, it is attached to a pair of vibrating arms which raise it while the hopper is making its dumping movement. In this way the dirt is thrown off. The view at the left shows the scraper entering the hopper, with the apron in horizontal position. The view at the right shows the scraper and hopper in the dumped position, and the apron raised to throw off any loose earth. A wagon to receive the material would stand at the left of the machine.



A Dragline Excavator with Wagon Loader or Dump

(The left view shows the scraper bucket entering the dumping hopper. The right view shows the hopper raised, and the apron (at bottom) raised to throw off loose dirt. (A) scraper; (B) hopper; (C) hopper arms; (D) apron; (E) hauling cable; (F) backhaul cable.)

Street Stop-Cock of the Boston Water-Works Department

By George H. Finneran*

In addition to the usual curb cock for shutting off services, the Water Division of the Public Works Department, Boston, Mass., is installing stop-cocks in the street over the mains. This practice has grown from frequent trouble with services in paved streets, between the main and curb

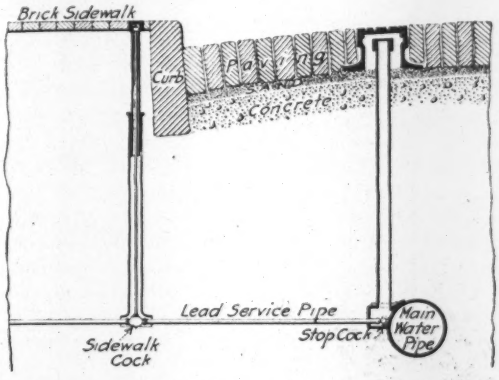


Fig. 1. Service Shutoffs of the Boston, Mass., Water-Works Department

cock, or at the curb-cock connection, which meant opening up the pavement to shut off the water and make repairs. Fig. 1 shows the general arrangement of the two shutoffs and Fig. 2 the details of the iron box casting for use alongside the main. The surface box is the usual cylindrical casting and cover.

The castings for different sizes of mains vary only in

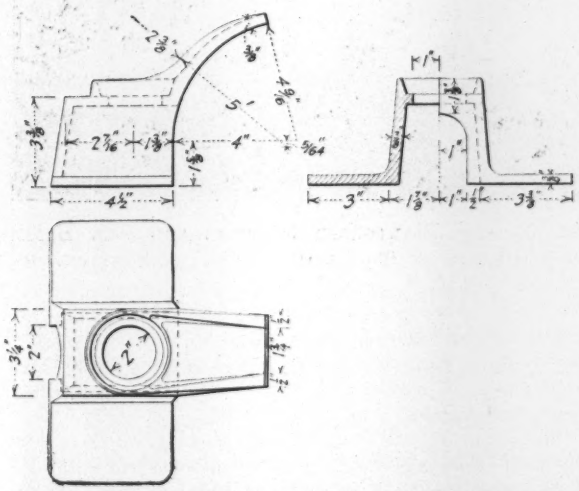


Fig. 2. Details of Casting for Covering Service Shutoff at Main

the length and radius of the rib which lies against the main. It is not secured to the main in any way and depends on the flanged footing and its own weight for holding its position. It is surrounded, of course, by tamped earth. Fitting into the top ring is a 2-in. iron pipe, terminating in the surface box. The cock is an ordinary corporation cock turned by a long-handled wrench.

*Assistant Superintendent of Water Service, Boston, Mass.

Notes on Concrete Road Construction*

A considerable mileage of concrete road has been built by H. J. Kuelling, Highway Commissioner of Milwaukee County, Wis., mainly on the day-labor system. He considers that rather too much attention has been given to thorough rolling of the subgrade, as the concrete slab will bridge over wet or soft spots. In his practice the only rolling is that done by tractors in hauling the graders or hauling material.

To insure the use of the full proportion of cement, the county furnishes the cement to the contractor, so that he has no object in skimping. As a check against waste or excess, however, he is held responsible within certain limits for an overrun of cement, and he is made responsible also for the care of all empty sacks.

The aggregate is of local material when possible. Stone graded from ¼ in. to 1½ in. is preferred for the coarse aggregate, with fine aggregate graded from ¼ in. downward. The use of pit-run gravel is not approved. The proportions used are 1 : 2 : 3½.

The use of hydrated lime or other inactive material is being considered, to increase the density without reducing the hardness of the concrete. Tests are to be made of the abrasive value of concrete of different proportions, in which hydrated lime is used. Steel reinforcement is considered necessary only in exceptional cases, as in wet ground.

The number of revolutions required in the mixing of the concrete should not be decided arbitrarily, as five revolutions with some mixers are as good as ten revolutions with others. Attention should be given also to the speed of the drum. For distributing concrete on road work, a spout is preferred to a bucket and boom, as the material is then delivered in smaller quantities and there is less tendency for separation of the aggregate from the mortar. If the concrete is maintained at proper consistency, which is such that it will flow easily but not run like water, very little finishing is required and one man can easily keep up with a good-sized crew. He should merely smooth out the markings of the strike-off board and remove any foreign matter from the surface. He should use a wooden float at least 18 in. long, and work such a distance back of the mixer that the concrete is about ready for its initial set.

The spacing of expansion joints has increased from 25 to 35 ft., and from 35 to 50 ft., with satisfactory results, and in Illinois the spacing has been increased from 50 to 75 and 100 ft. The necessity for steel protecting plates is doubted, for no matter how carefully they are placed, there is a tendency for the concrete to chip, thus requiring an almost immediate tarring of the joints. The joints of the future may have merely felt or paper, with a slight rounding of the joint (with an edging tool) which will be filled by the pounding down of the felt. The ability to get concrete that is homogeneous and impervious to water will have a marked effect upon the spacing of joints, as water content is more the cause of the movement in concrete than the changes in temperature.

After trying both gravel and earth shoulders, the latter are considered preferable for double-track concrete roads.

*From a paper at the 1914 Good Roads Congress at Chicago.

Tearing Down a 250-Ft. Reinforced-Concrete Chimney

A 250-ft. concrete chimney built in 1906-07 at the Torresdale Pumping Station of the Philadelphia waterworks, early began to show signs of decay, particularly in the lower 100 ft., which was erected in the winter without proper precautions against freezing. During the past year its condition became so precarious as to demand its early removal, so an adjacent brick chimney was erected

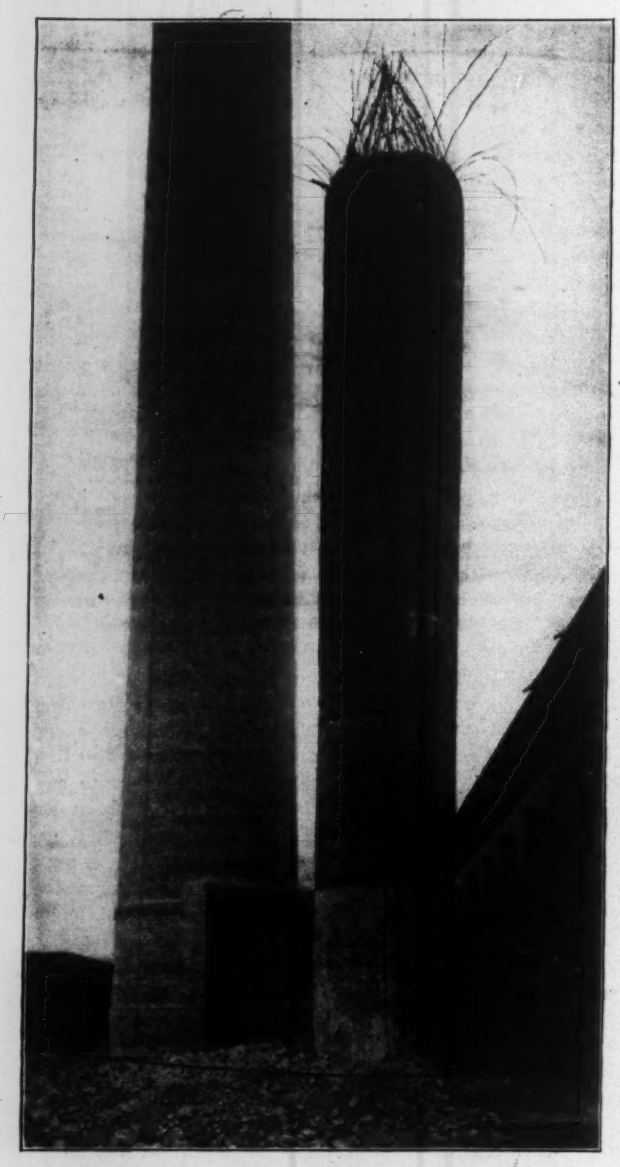


FIG. 1. CONCRETE CHIMNEY DURING RAZING
[Note scabby surface about midway up and well defined planes of lifts.]

and a contract entered into for the razing of the concrete chimney. On account of the proximity of the pumping station and other buildings it was impossible to throw the chimney down as a whole, but rather laborious piecemeal destruction was required. The figures of progress and cost herewith were furnished by Carleton E. Davis, Chief of Bureau of Water, Philadelphia.

The chimney was 251 ft. high above ground, with a

COST OF DEMOLISHING CONCRETE CHIMNEY, TORRESDALE PUMPING STATION

Cost to Demolish First 160 ft.		
72 men days @ $5.00 per day		$360 00
3 men days @ 1.75 per day		5 25
		$365 25
Average cost per foot	$2.20	
Cost to Demolish Lower 91 ft.		
35 men days @ $5.00 per day		$175 00
96 men days @ 3.50 per day		336 00
36 men days @ 1.75 per day		63 00
		$574 00
Average cost per foot	$6.31	
Maximum demolished for 1 day in top section 15 Ft.		
Maximum demolished for 1 day in bottom section 8 ft.		
Approximate Cost to Demolish Chimney		
Foreman 59 men days @ $5.00		$295 00
Mechanics 48 men days @ 5.00		240 00
Mechanics 96 men days @ 3.50		336 00
Laborers 39 men days @ 1.75		68 25
Rope, tools, powder, etc		100 00
Approximate total cost		$1039 25
Average cost per foot to demolish	$4.15	
Time required to demolish 250 ft., 59 working days		
Average per working day, ft	4.25	
Bid price to demolish was	$2,260	

91-ft. lower section of 12-ft. outside diameter and 10-in. solid walls and a 160-ft. upper section of 10-ft. outside diameter and 6-in. solid walls. The reinforcement consisted of heavy vertical deformed rods tied by closely

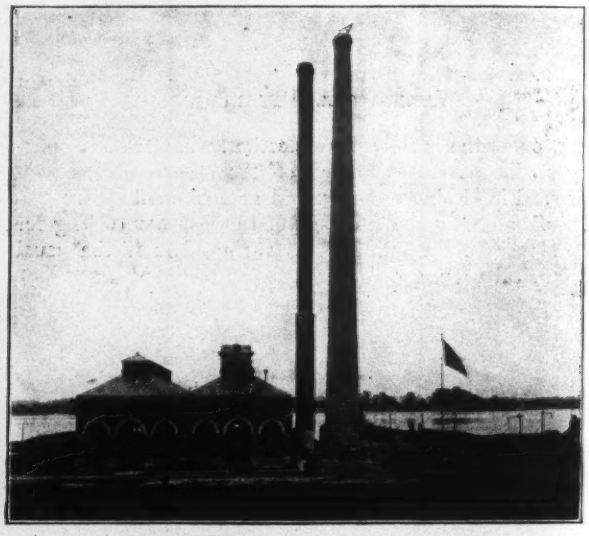


FIG. 2. OLD REINFORCED-CONCRETE AND NEW BRICK CHIMNEY AT TORRESDALE PUMPING STATION, PHILADELPHIA

spaced circumferential rods of smaller section. The construction was carried on in 5-ft. lifts, which made clear planes of separation; it was here that failure became first evident.

The razing was all done by hand by two and three men on the chimney top breaking down the concrete wall with sledges and bars and throwing the pieces over the side. The reinforcing rods were only lapped at the ends, and thus did not have to be cut or sawed. But very little of the concrete was hard enough to require blasting, but some sections made such difficult bar and sledge work that the wall was loosened up there by small shots.

There was no ladder to the chimney top, so the workmen had to work their way up the inside of the stack by successive short, slanting boards footing into holes dug into the concrete as the lifts progressed. Once the top was reached a line was rigged up by which the men went up and down.

While the concrete was below standard, particularly in the lower 100 ft. where the deterioration endangered the stability of the stack, the steel reinforcing rods were thoroughly gripped and showed no signs of rust when removed, except in those face sections where spalling had exposed the steel.

The tabulated data of progress and cost are shown by the table printed above.

Light Tractors for Construction Work

Some light and low-priced tractors now being introduced present possibilities for use on road and general construction work as well as for the agricultural work for which they are designed more especially. Such machines would be of advantage in many cases in hauling material to the work or distributing it on the work, and the caterpillar type of tractor can be operated successfully on soft ground.

The Bull Tractor

The light and convenient machine shown in Fig. 1 is of the three-wheel type, having a single steering wheel in front, a driving wheel on one side and a smaller carrying

Fig. 1. A 1½-Ton Three-Wheel Tractor Hauling a Road Scrapfr

wheel on the opposite side. It is built by the Bull Tractor Co., of Minneapolis, Minn., and the cut shows it attached to a road grader.

The machine has a forked frame and upon this is mounted a 12-hp. two-cylinder gasoline engine. There are only five gears, and the main pinion (with roller teeth) engages an internal gear on the bull-wheel or driving wheel, which wheel is 5 ft. in diameter and 12 in. wide. The opposite wheel is 40 in. diameter and the steering wheel is 28 in. The machine is about 12 ft. long, 6½ ft. wide and 5½ ft. high, with a weight of 3280 lb. It has been used experimentally in hauling road graders and road drags.

Bullock Two-Legged Caterpillar

A light tractor which has the peculiar feature of being carried entirely by a pair of caterpillars is shown in Fig. 2. As the caterpillars can be controlled independently, and thus made to move in opposite directions, there is great flexibility in steering and the machine can be turned in little more than its own length.

The 5-in. I-beam frame carries a gasoline engine of 10 to 15 hp., of the horizontal opposed-cylinder type. The engine can be run also with kerosene or oil distillate, being first started with gasoline. The caterpillar bands are 12 in. wide and have a bearing surface about 3 ft. 8 in. long, a set of rollers holding down that portion of the band between the sprocket wheels. The machine is about 8 ft.

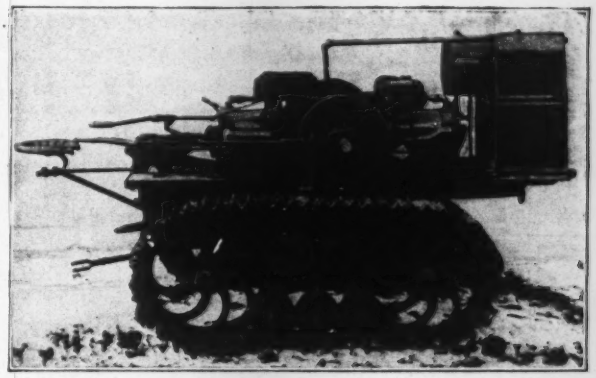


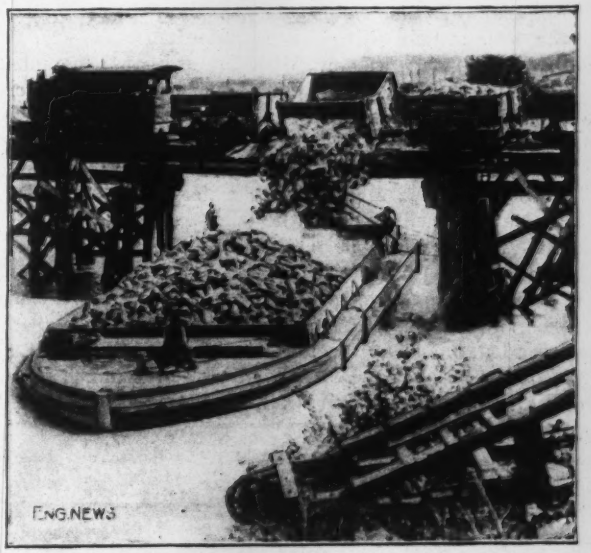
Fig. 2. A 2½-Ton Tractor of the Caterpillar Type

long, 5 ft. wide and high, and weighs 5200 lb. in working order.

This machine is known as the "Baby creeping grip" tractor. It is built by the Bullock Tractor Co., 1801 Diversey Parkway, Chicago, which also builds larger machines having caterpillars under the rear end and a pair of wheels under the front end.

A Durable Reinforced-Concrete Scow

While a number of reinforced-concrete scows have been built in the last few years, they have not all stood up well under the stress of wear. On the Welland Canal is such a scow which has seen very hard usage since 1910 and is now giving admirable service. The accompanying view



Dumping Stone into a Four-Year-Old Concrete Barge

shows the scow taking a 12-ft. dump of riprap stone, an indication of what it has had to stand.

This scow is 80x24 ft. in plan and 7 ft. deep. Its walls, which are uniformly 2½ in. thick and reinforced with ¼-in. rods, were poured between forms and were not plastered on the reinforcement as has been the practice in some similar work.

Dippers for Steam Shovels and Dredges

Modern developments of form and construction in the bucket or dipper used on steam shovels and dipper dredges* were the subject of a recent inquiry. A statement by the Marion Steam Shovel Co., Marion, Ohio, gives the following information.

The older types of dippers, before the days of steel castings, were made entirely of plates and forgings, and the capacity rarely exceeded 2 cu.yd. Changing conditions and requirements made necessary the employment of larger and heavier machines, which required larger and stronger dippers that could stand up under such severe work as excavating iron ore, stone, hard shale, etc. The first development was the dipper with plate front and a cast-steel back. Later the plate front was replaced with a manganese-steel casting. Manganese-steel teeth (both one-part and two-part) have been tried with more or less success, but a large number of operators, after experimenting with various designs, have gone back to the solid forged teeth. Cast-steel dipper bails have been used extensively.

Dippers vary according to the kind of work they are to be used in. In trench work the dipper bail is usually dispensed with and the hoisting line is hitched direct to the cast-steel back. In such instances the teeth are provided on the sides of the dipper, in order to cut a straight vertical bank. Dippers for coal mining are ordinarily made somewhat lighter than those used in general work, and are provided with special pick-point teeth, to avoid as far as possible the breaking up of the coal.

Dippers for handling stone and kindred materials are made very heavy and of rugged construction. They are much shallower than the usual type. For soft sticky material it is sometimes desirable, and often necessary, to design a dipper with more than the ordinary clearance, in order to make the dumping of material easy. In such digging, it is also customary to replace the teeth with a cutter or lip.

Dippers for placer gold mining must be so designed that the door and all joints are water-tight; otherwise, the fine gold will escape with the water and be lost. Usually, this is accomplished by means of a suitable gasket between the bottom of the dipper and the dipper door. A cutter or lip is also desirable on a dipper for this class of work whenever it is practical to use it. When teeth are used the material passing between them falls back to the bottom, and the gold carried with it is much more difficult to recover after it has been disturbed.

NOTES

Groundwater Pumping for a Sewer Trench in Quicksand—In building about four miles of sewer through marshy ground with quicksand subsoil, E. McShaffrey & Son, of Akron, Ohio, made effective use of the well-pumping method for drying the soil before excavation. The trench ranged in depth up to 17 ft. As the trench approached the bad ground, pipe wells were jetted on both sides of the line of the trench 3 ft. apart longitudinally. These were 1½-in. driven pipe connected by a larger header pipe above ground. A triplex pump drawing from the header pipe was able to take care of about 100 of the wells. Two hours' pumping before digging started dried out the ground enough so that the soil stood with only occasional local bracing.

The method was particularly expeditious because the well pipes could be put down very quickly. A well was sunk in from two to three minutes, so that the preliminary work for an entire section of trench could be done with little loss of time.

The soil seemed to be dense enough that the pumps could lower the ground water level locally below bottom of trench without exceeding their capacity in taking care of the inflow.

An Unusual Concrete Structure—An acid-tower group of reinforced concrete has just been completed for the Hammermill Paper Co., at Erie, Penn., by the Weber Chimney Co., Chicago. Four towers 10x99 ft. set in a square, 15 ft. c. to c., form the group, which is made a unit by a common foundation slab and a housing at the top embracing all four towers.

AN UNUSUAL CONCRETE STRUCTURE: ACID TOWERS OF A PAPER MILL

The towers are lined with special tile laid in acid-proof mortar, to resist attack from the acidulated liquor dripping through the stone filling of the towers. The footing slab is 32 ft. square by 6 ft. thick; its horizontal reinforcement is engaged by the vertical rods of the tower reinforcement, anchoring the towers. The stack shells are 9 in. thick, with ½-in. verticals and ⅝-in. rings of square twisted rods. The lowest tower section has 20 vertical bars in the circumference, but at the top these are decreased to 12 bars. The rings are spaced 5 in. apart in the lower section and 20 in. apart in the top.

The height is 99 ft. from foundation to tower top. A floor over the towers carries a housing 25 ft. 4 in. square by 7 ft. 6 in. high, where rock is stored. Over the housing in turn is a water tank 11 ft. square by 3 ft. high. Walls and columns support the roof.

*A dipper mounted on an all-steel dipper handle was noted recently in our columns.

Editorials

For the first time in the history of the Bureau of Standards, a detailed report on its manifold activities has been issued. It is a highly interesting pamphlet. Director Stratton is to be congratulated on successfully setting forth the variety of the Bureau's problems, and the close interrelations between his institution and the country's industries and arts.

A surprisingly large amount of work is being done by the Bureau in aid of engineering and construction questions. Among the newer ones are: Tests of steel columns, studies of soil properties to assist the foundation-soil committee of the American Society of Civil Engineers, practical study of alkali effects on concrete, scientific investigation of the set-producing constituent of cement, and study of the brass failures on the Catskill Aqueduct. There is stimulus in the report for everyone who deals with technical difficulties, certainly for every progressive engineer and industrial man.

What the Bureau has done is scattered at random over a large field of possibilities. Its fullest assistance to the constructive arts can develop only as the problems of practice are brought to its attention by requests for advice and help. Even now the facilities of its laboratories are fully taxed, but by wise selection among the problems offered it will still be possible to expand greatly the range of work done.

Meanwhile the report—issued by the Department of Commerce—ought to find wide circulation and reading.

Steel Platforms for Large Horizontal Turbo-Generators

Supporting large turbo-generators on a steel framework is a comparatively new development in power-station practice. Until about six years ago, practically all heavy machines were set on masonry foundations. The new type of foundation was born of the necessity of sometimes installing large units in the space left for those of a smaller capacity or a different type. With the steel structure, also, the space-consuming condenser can be placed conveniently beneath the turbine.

The so called steel foundation is not yet in general use, but it is fast gaining in favor. Not so long ago it was thought to be impracticable, if not indeed impossible, to design a framework capable of carrying successfully a rapidly vibrating load weighing from 300 to 400 tons.

The first attempt to accomplish this feat was made in Philadelphia about six years ago. Since then similar structures have been constructed for: Four units in the Kent Ave. station of the Brooklyn Rapid Transit Co.; three units in the 201st St. station of the United Electric Light & Power Co., New York City; two units in the Waterside No. 2 plant of the New York Edison Co.; one unit in the Marion station of the Public Service Electric Co. of New Jersey; and one unit in the Gold St. station of the Edison Electric Illuminating Co. of Brooklyn. In another part of this issue the salient features in the design of the steel foundations in several of the plants mentioned are described.

In all cases, the units thus supported are of the horizontal type. Very large turbo-generators are available in the horizontal type at less cost per kilowatt, on account of greater speed. It is doubtful whether a satisfactory steel platform of the general design described could be built to carry a vertical unit on account of the greater weight per square foot, and the torque consequent to a sudden stoppage, in the event of a short circuit.

The Pearl Harbor Dry Dock Construction

The novel method proposed by the Civil Engineers of the Navy for the construction of the Pearl Harbor dry dock, which is described on another page of this issue, is more remarkable in its application than in its conception, for the floating caisson has in the past few years become a familiar adjunct of marine construction. But never before, so far as we are aware, has the floating caisson been utilized for so enormous a monolith as the sixty-odd foot full-width section now proposed nor, so far as we know, has it ever been tried for dry dock work.

The disastrous history of the first attempt to build the dry dock along the conventional lines and the reputation and ability of the engineers who recommend the new plans combine to make the adoption of the floating caisson method more easily understood than it would be were engineers to study the method solely on its own merits, for it must be admitted that the hazards of construction loom fairly large. Unfortunately, the remote location of the work will make personal visits to it impossible to most engineers, and records of the progress made will certainly be awaited with interest.

Popular Courses in Highway Engineering

During the past two years we have given much space in the column devoted to Engineering Schools to outlining the short winter courses in highway engineering which several colleges have arranged for city and county engineers, and for various others in local practice who meet modern road problems. Since the opening of the present college year, we have been overwhelmed with announcements of these courses and have, therefore, necessarily refrained from describing any of them.

Practically every engineering school in the country this winter throws open its doors for from one to eight weeks, spreads broadcast through its region a hospitable invitation, and concentrates attention on road building and paving materials and methods, for the benefit of engineers and near-engineers who come seeking more knowledge. Thus has sprung up quickly one of the interesting developments in American engineering education and one

which calls forth admiration for a democratic readiness to serve in any way where need is found, without too much respect for some of the old academic barriers.

Concerning License Laws for Architects

One of the subjects discussed at the recent annual convention of the American Institute of Architects in Washington was the enactment of so called license laws governing the practice of architecture. Several states have enacted such laws; that of New Jersey, for example, has been in force for a dozen years. The Institute's committee which reported on these laws, while expressing a qualified approval of the general scheme, declared that unless these laws were improved in some respects and unless the profession kept an eye on their workings they might eventually become a serious hindrance to good architecture.

The chief criticism which the committee made on these laws is that they are generally framed with a view to protecting the public health and safety, this being indeed the only logical reason why the state has any business to interfere in such matters. The committee of the American Institute, however, very frankly confesses that an architect is primarily an artist and not a builder. The committee says:

> Most of the present laws define the qualifications of an architect in a way that would lead the public to believe that his principal duties are along structural and sanitary lines. While we know that he should have some knowledge of these matters, they are not by any means the principal qualifications of an architect. The architect is not the highest authority on construction or sanitation, but he should be on planning, grouping, design and color. Are not these latter requirements more necessary of possession by architects to help the public toward better architecture than knowledge of trusses and plumbing?

Honest confession is good for the soul, and it will be refreshing to many engineers without doubt to have this frank statement on record from the representative architectural society of the country that the engineer and not the architect should be the supreme authority on the safe construction and wise planning of a building and its equipment. As the laws now stand, however, they proceed on the theory that the architect is the final authority in these matters of strength of trusses and columns, and safety of sanitary plumbing. Hence, in the states which require architects to be licensed, the engineer who desires to engage in the construction of buildings, even though they may be purely for utilitarian purposes and devoid of any architectural pretensions, must either take out a license as an architect himself or get some architect to sign his plans.

This situation has led some engineers to favor the enactment of laws requiring the examination and registration of engineers as well as architects. Those who thus argue, however, appear to us to overlook the fundamental fact that architecture is substantially one profession, while engineering at the present day is a dozen or twenty or a hundred professions instead of one. It might be feasible to examine and register engineers engaged in the construction of buildings as architects are now examined and registered in a few states; or to examine and license engineers engaged in the laying out of irrigation systems, or engineers who engage in the practice of land surveying, or engineers who design and construct sewerage systems; but when it is proposed to give an engineer an examination and then issue to him a formal state certificate attesting his competency to practice any branch of engineering from building a subaqueous tunnel to laying out a railway interlocking plant and from running a line of precise levels to designing a speed-change gear for a turret lathe—when such a proposition is stated in plain terms its absurdity is evident upon its face.

Grading Engineers in the New York City Service

Elsewhere in this issue we report the work undertaken by the Board of Estimate of New York City in classifying all the employees of the City. The matter is of special interest to engineers since the Bureau of Standards, which is doing the classification, has begun by classifying and standardizing all the city engineering work and employees.

With the general aims of the Bureau of Standards, every worker for good municipal government will have entire sympathy. One of the great difficulties in securing efficient and economical city government is not alone the uncertain tenure of official positions, but the fact that appointment and promotion are dependent on other things than ability and efficiency. But good intentions do not necessarily produce good results. The chief thing to be feared from the standardization plan as outlined by the Bureau of Standards is that it may place too much authority over matters of appointment, promotion and salary increase in the hands of an outside bureau and thereby prevent the men who are in responsible charge of work from properly controlling the men under their direction. Complaint is general among engineers in public service, and has often been voiced in our columns, that the civil-service laws now in force have to a great degree hampered the work of the men in responsible charge so that they have not a proper voice in the selection of their own assistants or in their promotion.

A report on this proposed scheme of standardization, as far as it affects the engineers in the city service, has been made by the committee on salaries and grades of the Municipal Engineers Society, of which Alfred D. Flinn is chairman. The following quotations from the report of Mr. Flinn's committee are of special interest:

> In all vocations, the ablest men will be attracted to places offering greatest opportunity for development of individual excellence and greatest reward for excelling. Freedom in performance, direction and control of work is also important to such men, and must extend in some degree to selection of assistants because many qualities of fitness, personality and character are not detectable by examination.
>
> The public employment loses many of the brightest men who enter it and accumulates those of average and less than average ability. The best system will not avoid this result in any great organization, public or private, if the system be slavishly followed so that it becomes the master and not an instrument for securing the best possible service.
>
> Men in authority and their chief lieutenants should have sufficient voice in the application of any system to adapt it from time to time to the needs of their work. No bureau can be competent to appraise all services in the extremely varied activities of New York City. If such a bureau were established, its powers might become objectionably great unless checked. The control of the staff of a department should not by indirect action be taken from the responsible head and virtually lodged in an auditing or appraising body, or in an employment bureau.

We believe this general criticism will be approved by every engineer who has the responsibility of controlling a large staff of assistants.

Letters to the Editor

An Association of National Engineering Societies

Sir—I have read with interest the editorial in your issue of Dec. 17, referring to the work of the Coast and Geodetic Survey. That this important work has never been given due recognition, even by many engineers, to say nothing of laymen, is well known. The fact, therefore, that Secretary Redfield and President Wilson have called attention to this work and of the necessity that it should be prosecuted under favorable conditions, and that its records should be securely guarded, is gratifying.

It seems, however, altogether vain to express the hope, as is done in your editorial, that the national engineering societies, at least as now constituted, will take any steps to reinforce the recommendations of President Wilson and Secretary Redfield. This, however, is only one case out of a great many which tends to show that it is time that engineers should take some concerted action for the formation of a national association embracing all the branches, Electrical, Mechanical, Mining, Civil, etc., with officials known for their prominence in business and civic affairs as well as technical engineering, which will make it its business to promote in every way the legitimate interests of the profession.

It is altogether too often assumed by laymen, though not, it must be admitted, without some cause, that engineers are only technical men and do not have a broad outlook, or have little business sense. Many examples can be brought forward, of course, to prove that there is just as great a proportion of broad-minded engineers, and engineers with business sense, as there is of the members of any of the other professions; but so long as we sit back with folded hands and say resignedly that everything except looking through a transit or designing a structure, or writing a professional paper is unprofessional, just so long will the general public accept us at our own estimation.

It should be entirely feasible to form a national engineering association or an association of national societies, which will be influential enough to make itself heard on questions of national and state policy involving engineering questions, and which will consider this as part of, and probably the most important part of, its duties. It is to be hoped that engineers of all kinds and all engineers will give this matter some little thought and make a continuous effort to achieve this result. If we keep hammering at it long enough, we shall get it.

F. Lavis.

50 Church St., New York City, Jan. 2, 1915.

[In our opinion, the engineering profession need not wait for its national societies, with their more or less cumbersome organizations, to move in matters of this sort. Here is the opportunity for the local engineering societies, on whose growing importance we have recently commented, to do effective work. Memorials from the engineering societies of Cleveland and Philadelphia and Boston and Scranton, and half a dozen other cities would undoubtedly have weight with a Congressman, quite as much, very likely, as actions by a national society whose standing might be wholly unknown to him. The Secretary of Commerce and Labor has appealed through the columns of Engineering News for support of the Coast Survey's work by the engineering societies of the country. Surely such an appeal is an opportunity for the profession.—Editor.]

Five Years' Satisfactory Experience with a Gravel and Oil Mixed Pavement; Concord, Mass.

Sir—My attention has been called to an article in Engineering News, Nov. 26, 1914, entitled "Notes on Massachusetts Highway Work." In the paragraph p. 1059, on gravel and oil mixed roads, you state:

> In 1910 the town of Concord laid down on Main St. a pavement surface made of a mixture of gravel and hot asphaltic oil binder, the work being done under the direction of the Highway Commission's engineers, and this pavement is still in excellent condition.

This statement is incorrect in the following: The pavement was built in June, 1909, not in 1910, and under my supervision after some consultation with F. C. Pillsbury, Division Engineer, Massachusetts Highway Commission. It was paid for out of the anuual appropriation of the town of Concord for roads and bridges. I inclose a brief description of the construction methods. The pavement has certainly proved very satisfactory in this instance under severe traffic conditions.

The piece of pavement described is in the middle of the town in the business section, with car tracks in the center of the street. The pavement therefore not only gets all the through traffic, which amounts on pleasant Sundays and holidays to 700 motor vehicles an hour, but in addition all the year round a great deal of heavy market teaming by the truck gardeners supplying the city of Boston, and all the local traffic composed of light delivery wagons and heavy wagons carrying ice, coal, wood, etc., all on narrow iron tires.

This section of pavement is 400 ft. long and 50 ft. wide including the car tracks. The foundation is an old waterbound macadam road 4 in. thick, which had been in about ten years and was badly rutted and very muddy in wet weather. The old macadam was first thoroughly scraped with a road scraper and all depressions and ruts leveled with hoes. On top of this was applied a 4-in. bituminous coating consisting of washed gravel and Standard Oil Co. Binder "B" (90% asphalt), both ingredients being heated and mixed at the gravel pit. The oil was heated to about 300° F. and the gravel thoroughly heated without burning. The proportion used was 50 gal. to a load of gravel (1⅓ cu.yd.). After being thoroughly mixed this was carted about 1¼ miles, spread on the road and rolled with a garden roller weighing only 300 lb.

This work was done in June, 1909, and no repairs have been made, with the exception of a filled-in sewer trench, where some settlement occurred, and a few places where horses stand, the urine of which seems to disintegrate the material.

The first cost of this work was 65c. per sq.yd., the oil costing 9½c. per gal. in barrels per carload lot, and gravel 10c. a load. We have done similar work since under more favorable conditions for 54c. per sq.yd.

The cost of repairs made on this section for the five years of its existence has been $20 in round numbers; and today it is in first-class condition showing very little sign of wear even close to the car rails. In cutting through this pavement for a sewer trench the past season, it was found that the wear was less than ¼ in.

I think that a smoother and better finish could be obtained by the use of a 6-ton tandem roller on this class of work.

JOHN M. KEYES, Chairman,
Commissioners of Roads and Bridges.

Concord, Mass., Dec. 26, 1914.

The Latest Design of the Herschel Fall Increaser

Sir—Your readers of p. 1134 (ENGINEERING NEWS, Dec. 3) should have been, and I think should yet be favored with a drawing of the fall increaser of recent date (not of 1907, printed June 11, 1908). Such a one I place at your disposal.

The 1907 design was the first one ever made of a "fall increaser," and was made anterior to the tests conducted at the Holyoke public testing flume.

Following these, it appeared that there was no need of constructing discharge channels for the turbine discharge, to be used at times of low water.

The velocity of the water through the holes in the fall-increaser casting is only 4 ft. per second as a maximum (3 in. or less loss of head), and that may be assumed as part of the price to be paid for the advantages to be created by the use of the fall increaser, amounting in cases to an average of tens and hundreds of thousands of dollars annually, forever.

This form of construction also reduces first cost materially, and makes of the fall increaser but little more than a culvert under the power house.

It should also be made plain to engineers that the method of the several "ejector flow increasers," built since 1907, was tested in 1905, at Geneva, Switzerland, it then having been called "l'Usine-Barrage, Systeme Saugey." Its efficiency is about 3%, or so small that the instrument may, I think, be called, as I have called it, "worthless"; whereas the maximum efficiency of the "fall increaser" so far obtained, has been found to be 30.4%. If we add that the costs of the two do not differ materially (see the accompanying cut), then no proper inducement has existed these six or seven years, when wishing to utilize the power of freshet water, and to overcome the evil effects of back-water, to build other than according to fall-increaser designs.

CLEMENS HERSCHEL.

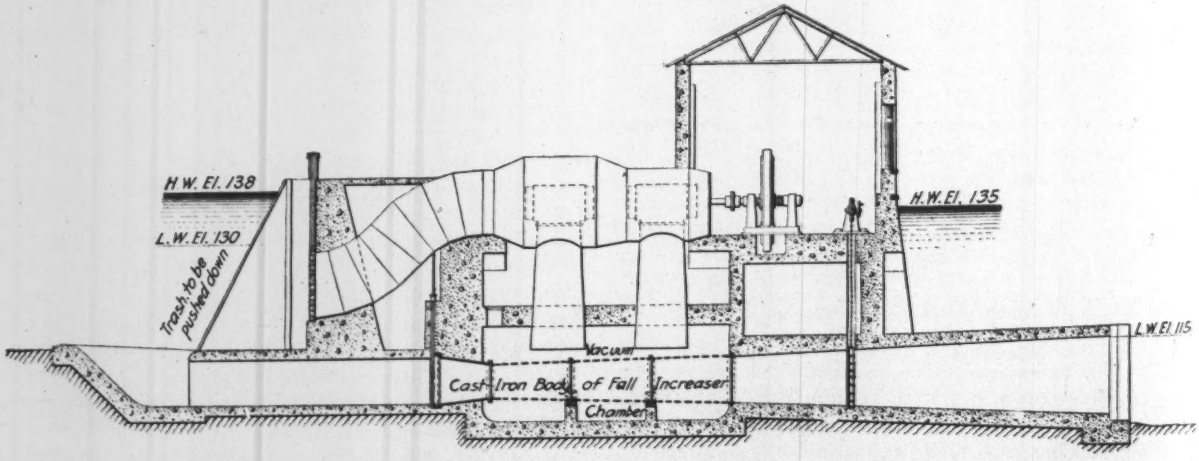
2 Wall St., New York City, Dec. 8, 1914.

Formulas for Locating Frogs and Switches

Sir—Referring to the article in your issue of Nov. 5, 1914, p. 926, entitled, "Formulas for Locating Frogs and Switches on Circular and Tangent Tracks," by Anders Bull, the title appears to be a misnomer. The article in the premise starts with the location of the switch known, and deals merely with the relative location of the switch point and frog, or, in other words, with the switch lead.

Throughout the demonstrations given, the lead curve is considered tangent to the main track, and to the frog at the frog point, a fallacy the present writer considers serious, and one that every practical track engineer and foreman recognizes. The assumption of the article under discussion, and of nearly all of the field-book writers, dates back to the time of very short frogs and stub switches, and is just as obsolete.

The switch rail and frog are straight. This fact and its effect on the length of the lead and the degree of the lead curve is very material. The American Railway Engineering Association in the formulas for switch leads, given in its "Manual of Recommended Practice," considers the switch rail and frog straight, as they are made, and the tables of recommended standard switch leads are computed on this basis.



CROSS-SECTION OF HYDRAULIC POWER STATION, SHOWING APPLICATION OF HERSCHEL FALL INCREASER

(The drawing also shows a siphon penstock. Note the very small amount of fall at extreme high water.)

Considering the scope of railway curves, it is generally proper to make the length of the lead the same on curves as on tangents. For all practical purposes, the degree of the lead curve from the inside of a curved track is equal to the degree of the lead curve from a straight track plus the degree of the curve of the curved track. And conversely, the degree of the lead curve from the outside of a curved track is the degree of the lead curve from a straight track, less the degree of curve of the curved track. The case where the above is not sufficiently accurate for working purposes is unusual.

The writer has not computed the difference between the results that would be obtained by the proposed formulas and similar formulas for similar conditions where the straight switch rail and frog are considered, because he does not believe it worth while. However, he is strongly of the opinion that, with all their refinement, because of neglecting the fact that the frog and switch rail are straight, the proposed formulas would give results further from the truth than indicated by the simple rule outlined above.

The designing and field engineer are generally not concerned with the length of the lead. That is properly fixed by standards. They are little concerned, too, with the degree of the lead curve, further than to avoid a combination of frog and track conditions that will give too sharp curves as determined by the rule just recited. The problem that really does confront the designing engineer and the field engineer in particular, is this: Given certain tracks of fixed positions, to so locate frogs of fixed angles that the connections after leaving the heels of the frogs are the best, or are at least such as to give practicable working conditions.

The most serious mistake made in the whole consideration of frogs and switches starts with the assumption that the switch rail and frog are curved. This has led to the attempt to solve all track problems (whether those between the switch rails and frogs or beyond the frogs) as though track connections were made with a continuous simple curve from point of tangency with the main track to point of tangency with the connecting track. All practical track engineers and men know the futility of this. There is nothing else that has caused and still causes so much of the disrepute in which track engineers are held by the track supervisors and foreman who attempt to put in track connections to stakes whose location has been computed by this method.

In his book, "Track Formulas and Tables," the writer attempted to show that it is just as simple and easy to compute frog and switch locations where the switch rail and frog are considered straight as to neglect this. And that for connections beyond the frog the track engineer should work from the heel of the frog. From personal experience in staking out and putting in hundreds of switches, and in the design of many yards, the writer knows that this method is practicable and satisfactory and that stakes so set may be followed by track foremen to obtain connections that look right and are right, and fit without fudging.

The writer has given a great deal of thought to the subject of track connections, and from his thought and experience, and from the experience of others as far as he can learn, any track formula that does not take into account the straight switch rail and straight frog is misleading, generally impracticable of application, and should be avoided.

S. S. ROBERTS.

BERRY, HOWARD & ROBERTS, Consulting Engineers.

Chicago, Nov. 10, 1914.

[In accordance with our usual practice the above letter was referred to Mr. Bull. His reply is given below.—EDITOR.]

Sir—I have read with interest Mr. Roberts' comment on my article on "Formulas for Locating Frogs and Switches." In problems of the kind referred to, the location of one point (the switch point or the frog point) must be given or assumed, the problem being otherwise indefinite. Having determined the lead, by means of the formulas, we have all the information required for locating the other point, so I fail to see in which respect the title is a misnomer.

Mr. Roberts objects to the generally adopted way of treating track problems, by which the turnout circle is assumed as being tangent to the main track and to the frog at the frog point, on the ground that this condition does not correspond to the actual layout in the field. As anyone familiar with the method knows, this assumption is made only for the preliminary computations. The results thus obtained, being not intended for the field layout, should not be furnished to the foreman. The track engineer doing so would rightly be blamed.

The results are to be used only as a basis for the actual layout, tangents being inserted at the frog and switch and another value substituted for the theoretical radius. Having located the turnout under the first assumption, however, the latter part of the work is simple and calls for no detailed explanation.

I believe that treating the problems to which my tables refer in the way suggested by Mr. Roberts, would lead to unexpected difficulties, as they are all what he calls unusual cases, as the rule about the sum or difference of the degrees of the curves is not applicable to any of them. On the other hand, by solving first for the theoretical values, the work may be laid out according to fixed standards and the mental strain is reduced to a minimum.

ANDERS BULL.

New York, Nov. 19, 1914.

The Election in the American Society of Civil Engineers

Sir—Referring to Mr. Molitor's reply to my letter of Jan. 2, published in your issue of Jan. 7, relative to the contest in the American Society of Civil Engineers' election:

Mr. Molitor raises the question of the number of members of the nominating committee from any district, stating "as a matter of fact there are but two members of the nominating committee from any district." This statement is not correct if the five past-presidents who are members of the committee are considered as being from the districts in which they reside. The three members in District No. 1 referred to in my letter were the two specially elected representatives from the district and the one past-president who resided in the district at the time of the nomination.

A. W. CARPENTER.

New York, Jan. 11, 1915.

Proposed Method of Constructing Pearl Harbor Dry Dock

SYNOPSIS—Extraordinary scheme for building Pearl Harbor dry dock, Hawaii, devised by Bureau of Yards and Docks, U. S. Navy Department. Original dock bottom, of concrete placed under water inside of coffer-dam, blew up in February, 1913. Present scheme involves construction of heavily reinforced-concrete box on temporary floating dry dock and the sinking of a superposed coffer-dam fastened to this box, which forms one section of the bottom of the dock. Full details of scheme, which was first suggested by Civil Engineer F. R. Harris, U. S. Navy and which is partly due to the late Alfred Noble, who visited the site just before his death and partly to various Civil Engineers of the U. S. Navy.

On Feb. 17, 1913, a blowout in the bottom of one of the coffer-dams used in construction of the new United States naval dry dock at Pearl Harbor, Oahu Island, H. I., stopped all construction work on the dock. From that time until late last year a series of investigations has been under way, mainly under the direction of the Bureau of Yards and Docks of the U. S. Navy Department, and on Nov. 25, 1914, the department signed a supplemental agreement which provides for a new design for the Pearl Harbor dry dock. The conditions surrounding the failure of the first dry dock and the studies leading to the new design are of great interest.

Original Foundation

The Pearl Harbor dry dock was originally planned (see Engineering News, Dec. 9, 1909, p. 636) to be 1100 ft. long, divided into two sections by means of a central gate. The contract was awarded to the San Francisco Bridge Co. in 1909 for a dry dock 600 ft. long, and the following year this dock was increased to 800 ft. with an increase in breadth. Construction on that dock was started in 1910. It was to be built as a solid concrete structure with a heavy mass concrete floor to act as an inverted arch. All of the Hawaiian Islands are volcanic and the site of the dry dock was a heavy lava rock plateau about 15 ft. above tide level and 15 or 20 ft. in thickness. As it was originally deposited as a volcanic flow it has in it layers of broken coral, lava rock, lava mud, etc.

The site was first excavated to subgrade by dredging. It was then divided into four sections 148 ft. wide (the total out-to-out width of the dock) and 200 ft. long. Heavy timber cribs were sunk into the excavation, 12-in. sheetpiles driven around them, and the space behind the sheetpiling back-filled. It was then the intention to pump out the coffer-dams one by one and build the side-walls and bottom of the dock inside of them.

On completion of the cribwork and sheeting for the first section an attempt was made to unwater the dam. When this had been lowered about 17 ft. the cribwork started to rise and pumping was discontinued. Previous to this no piles had been driven in the foundation, but at this time on account of the conditions which arose permission was given to drive piles over the entire bottom and to deposit 8 ft. of concrete, that is one-half of the dock floor, under water through tremies.

Section 1 was then partly unwatered to a depth of 37 ft. Considerable leakage occurred through the concrete, which on inspection was found unsatisfactory. The leakage increased so much that the pumps available could not take care of it and the section was flooded.

At this time an appropriation was procured for the increasing of the size of the dock so that it was decided to

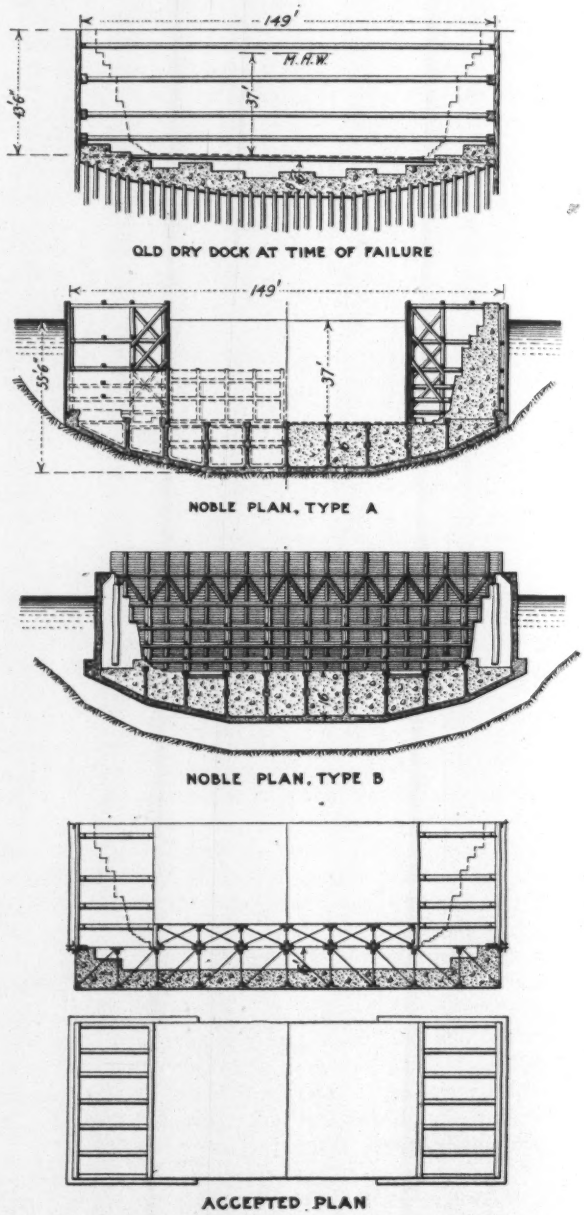


Fig. 1. Various Sections through Pearl Harbor Dry Dock, Showing Different Methods Used and Proposed for Construction

build it for 1000-ft. length; that is, a fifth section of coffer-dam was added. Accordingly the contractors started the work on Section 2, driving piles and depositing concrete under water by tremies, at the same time removing all the lean unsatisfactory concrete in Section 1. On completion of Section 2 (with the 8-ft. bottom as permitted), unwatering of the section was begun in the first part of February, 1913 (Fig. 1, *a*). After the water in the interior had been lowered slightly over 30 ft. the entire section began to rise slowly at first, but more rapidly as pumping continued. Pumping was stopped and an attempt made to flood the section, but this time the rising had become marked and rapid and the entire section rose several feet and collapsed.

Investigations

Shortly after the failure the Chief of the Bureau of Yards and Docks, Civil Engineer H. R. Stanford, U. S. Navy, accompanied by Civil Engineer F. R. Harris, U. S. Navy, visited the site to examine the conditions there, and after investigation reported that the failure was due to hydrostatic pressure, which overcame the weight of the concrete bottom and the grip of the anchorage piles. Messrs. Stanford and Harris reported that it was possible to build the dry dock in accordance with the plans and the methods being followed, but that it would entail changes involving the placing of more concrete by tremies and possibly the loading of sections by removable ballast.

In July, 1913, Civil Engineer Harris submitted a report to the department in which he suggested the abandonment of the previous plan of building the dock and suggested its construction by floating caissons, dividing the entire dock into ten sections, each section to be constructed in a separate caisson which should be built and launched and the sides built up and lowered to place in proper alignment by filling with concrete masonry; the spaces between the sections were then to be filled with tremie concrete.

Somewhat later a board, consisting of Civil Engineers Harris, Gayler and Gordon, who had made tests and investigations at the site, reported that the site was suitable for construction of the dock as intended but there would be reason to expect some unequal settlement and resulting cracks which would be unsightly and might shorten the useful life of the structure.

Noble Report

In August, 1913, the Navy Department requested the late Alfred Noble to visit the site, examine and report upon the general situation, and recommend procedure for completing the dry dock. Mr. Noble spent 12 days at the site during which period additional borings and tests were made under his direction. He reported to the department on Oct. 20, 1913, and recommended the adoption of a floating-caisson method of construction similar to that proposed by Mr. Harris. His recommendations for the future carrying on of the work were, in his own words, as follows:

> **A different method of construction should be adopted; one that will be safe at every step in the construction and afford a satisfactory dry dock when completed.**
>
> **Two general methods have been suggested and have been studied in connection with this report. One of these provides for building the dock in sections, each embracing the full width of the dock for a length along the axis of, say, 100 ft., more or less; the other method contemplates the use of concrete blocks, built above water, and placed by means of the powerful derrick now at the station. The spaces between blocks would be filled with tremie concrete and the reinforcement inclosed in the finished floor.**

Mr. Noble submitted two studies for the first-named method, Type A and Type B, which are shown as Fig. 1, *b* and *c*. The principal steps in the construction of the Noble Type A plan are as follows:

> **The first step would be to build an open caisson of reinforced concrete of the full depth of the finished concrete floor, to be sunk in place, and when completed to form a section of floor and a base for corresponding sections of the side walls. It is massive, having a floor 2 ft. thick and side walls 1½ ft. thick. Interior longitudinal and cross walls 1 ft. thick, spaced generally 14 ft. c. to c., divide the interior into pockets open at the top. The floor and all the walls are strongly reinforced. Such a caisson will be of great strength, and with its coffer-dam will weigh nearly 6000 tons. It would be preferable to build the caisson in a floating box or dry dock rather than on launching ways. If thus built and any leaks were found in the concrete structure when admitting water to the dock it could be unwatered, the defective place made good, and all risk from this cause averted. It would be floated without shock or contingency of any kind.**
>
> **The bottom of the dock would have to be carefully prepared to receive the caisson.**
>
> **The caisson with its coffer-dam would then be sunk to the bottom by filling it with water, control of the sinking being maintained by means of a central coffer-dam which subdivides the caisson.**
>
> **The placing of concrete in the pockets of the caisson would then be proceeded with by means of a tremie. When the pockets are filled the end coffer-dams could be pumped out, the sidewalls of the dock built in the open air and the coffer-dams removed. Closures in the bottom between adjacent sections would be made by tremie, and in the side walls by concrete placed in the dry with the use of bulkheads.**

The Noble Type B caisson construction was similar to Type A, with the principal difference that this caisson was to be sunk under the weight of concrete built in place, instead of being sunk by admitting water. This type required considerably less reinforcement and coffer-dam work than Type A, and would obviate the use of tremie concrete except in closures between sections.

> **With a plant and working force capable of placing 1000 cu.yd. of concrete per day it would require 10 to 12 days to sink the caisson. The risk of accident during the period would be appreciable, and this constitutes the most unfavorable feature when comparing it with Type A with its period of hazard of only a few hours. This disadvantage is offset to some extent by a reduction of cost by placing the floor concrete in open air instead of using the tremie as required with Type A. This would not only effect a saving of $100,000 to $150,000, but would improve the quality of the work. * * ***
>
> **The caisson plan submitted by Mr. Harris shows a much lighter construction than that proposed in this report. This reduced weight facilitates launching the caisson from ways instead of floating it in a floating dry dock. The lighter construction increases the danger of leakage from strains in launching and during subsequent handling. * * * * I am not mentioning these differences as being extremely serious; I believe the plan is practicable, but involving rather more risk in construction than Type B because the caisson has less strength, and, if built on ways, has in addition the launching risk. I believe that the additional safety in floating the caisson and in permitting a heavier and stronger construction which the floating dry dock affords is well wort'. its cost as an item of plant. * * * * In my opinion, one feature of the construction proposed by Mr. Harris should be changed radically. This is the use of lean, porous concrete to fill the pockets of the caisson and to form the side walls. There has been abundant experience to show that concrete will disintegrate where sea water seeps through it; and in sea-wall construction, where subject to varying water pressures tending to produce seepage, it is necessary to make the concrete practically impervious. This cannot be done even under the most favorable conditions if the proportion of cement to sand is less than 1:2½. This defect in the plan is easily remedied and does not affect the practicability of the proposed method of construction. * * * ***
>
> **The principal objection to the plan for construction by means of precast concrete blocks placed by derrick lies in the large number of joints extending through the masonry. The horizontal joints in the sidewalls formed in tremie-placed concrete would contain more or less defective material. There is no reason to doubt that the dock could be made water-**

tight, but perhaps after considerable time and expenditure, and it would not be expected that the completed dock would have the same degree of permanence as if built by one of the caisson methods. On the other hand, the cost might be considerably less.

In preparing a general plan for continuing the construction of the dock I have deemed it important to present one by which hazards during construction will be avoided as far as practicable and a structure provided which will be adequate and permanent. * * * *

Risks during construction would be avoided to a satisfactory extent by the block construction, but the completed work with its numerous joints could not be expected to be as permanent as if built in larger sections. Either of the caisson methods would give a better dock with little or no additional risk. The highest degree of safety at every step in the construction would be secured by the adoption of the Type A plan, * * * * but the added risk with Type B is not great * * * * and some reduction in cost and betterment in quality of work would be effected. * * * *

Adopted Plan

After considerable delay the Navy Department gave consideration to the adoption of the plan recommended by Mr. Harris and improved by Mr. Noble of constructing the dry dock by floating-caisson method. Meanwhile, in March, 1914, Civil Engineer L. M. Cox, U. S. N., designed and detailed a method of construction for carrying out the contract design. This method involved the use of a steel ballast tank 98 ft. square in plan, with wooden inclosing coffer-dams which would provide working chambers for building the sidewalls. The tank was to be supported either on timber grillage or upon steel construction, so as to form tunnels about 12 ft. wide and 10 ft. high, in which transverse reinforcement for the dock floor would be placed and the concrete of the floor completed.

By this time, April, 1914, the department had in hand enough suggestions of various sorts to enter into agreement with the contractor. Accordingly, on Apr. 13, 1914, the Chief of the Bureau, H. R. Stanford, presented to the contractor a method of construction prepared by himself but based largely on the various suggestions presented, and particularly on the original suggestion presented by Mr. Harris, with the modifications of Mr. Cox. The plans were approved by the contractor through his engineer, F. B. Smith, who also contributed some valuable suggestions. Mr. Noble's death prevented his approval of this particular design.

The scheme which will be undertaken and for which an additional contract of $1,261,350 was signed on Nov. 25, 1914, by the San Francisco Bridge Co. and the Navy Department, calls for a dry dock 1029 ft. long, 138 ft. wide from inside to inside of coping. The main difference in section from the old dock is that it has a flat bottom, resting on a bed of stone and gravel 1 ft. thick leveled over timber piles. This dock is to be built by floating caissons, the main structure being divided into 16 sections. The pump well itself will be constructed in the 17th section. The adopted method is shown diagrammatically by the use of models in the accompanying figures. The principal features of the adopted plan are as follows:*

(a) The dock is to be built in sections 60 ft. long and full width of the dock—152 ft. There are to be 16 such sections, placed about 5 ft. apart.

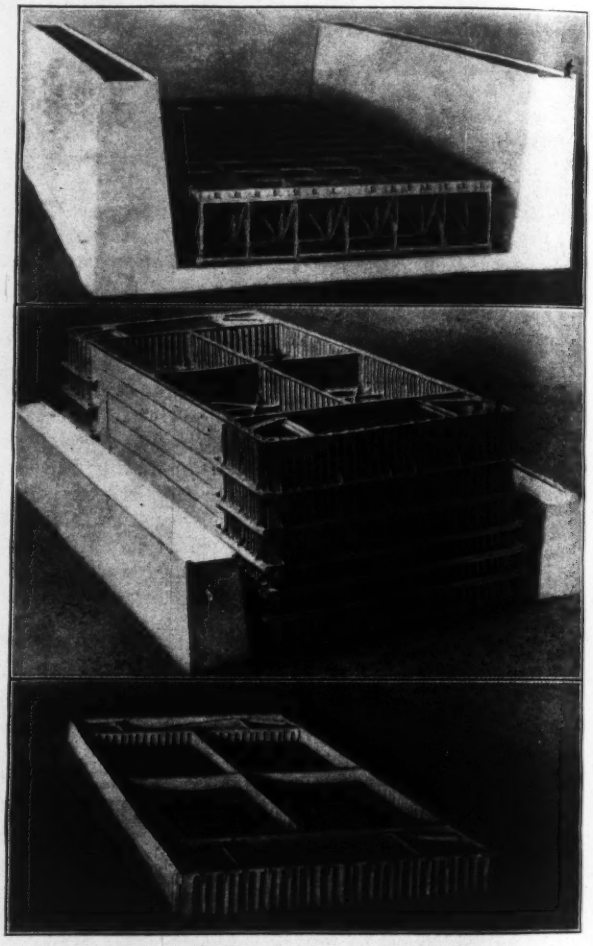
(b) The base of each section is formed by a system of structural steel trusses extending across the dock, with steel bracing lengthwise of the dock, together with the embedding concrete of the dock floor, which will be 16 ft. thick and flat on the bottom. The steelwork of each section weighs approximately 150 tons.

*From a paper by Civil Engineer E. R. Gayler, Civil Engineer, U. S. Navy, prepared for the department.

(c) The bases will be built upon a floating dock, designed for this specific purpose, to be provided by the contractors as a tool for use during the construction of the dry dock. The steelwork of the base, erected on the floating dock, is shown in the view of the model in Fig. 2.

The concrete at the sides and ends of the base will be carried up to the full height of the base, forming a heavy inclosing wall, and to about half height, or 8 ft., in the middle portion. The average thickness of the concrete of the base, completed to this extent, will be about 10 ft., and its gross weight will be about 7600 tons; but, due to its partial submergence, the net weight carried by the floating dock at this stage will be less than 5000 tons.

(d) The floating dock, carrying a base completed to the extent described in the preceding paragraph, will then be sunk to an extent sufficient to receive the ballast tank and coffer-



Figs. 2-4. Models Showing Progressive Sinking of Coffer-Dam for Pearl Harbor Dry Dock

(Upper view showing steel framework of base on floating dock. Middle view showing tanks and coffer-dam on base in floating dry dock. Bottom view showing ballast tank and coffer-dam sunk in place.)

dam structure. This is a strongly braced steel structure, consisting of a ballast tank 60x108 ft. in plan, with integral end coffer-dams forming working spaces for building the side walls. The total width over the plating of the end coffer-dams is 152 ft., and the total height of the structure is 45 ft. To the bottom of the tank are secured steel pedestals 8 ft. high (Fig. 5), designed to rest on the top chords of the transverse trusses of the dock bases, thereby providing a working chamber for completing the dock floor. The end coffer-dams have no bottom, and extend downward to about 7 ft. lower than the bottom of the tank, the two sides of the tank being also extended downward in the form of fixed aprons, so that the bottom outside line of the entire structure is in the same horizontal plane with the bottom of the

pedestals. The entire structure will weigh approximately 1,750,000 lb. and will cost about $90,000.

(e) The floating dock now being submerged to a depth of 28 to 30 ft. over the deck, the tank and coffer-dam structure is floated into place exactly over the previously prepared base. The floating dock is then pumped up, the structure being guided into place by means of tapered steel guides fitted on the outside of the aprons and the coffer-dams. In the joint between the base and the structure resting upon it there is a lead gasket, previously placed. The pumping is continued and water also removed from the interior of the upper structure until the joint is above water and exposed to view, when it is made secure by means of holding-down bolts. This condition is shown in Fig. 3. The holding-down bolts can be seen in this view, extending from the upper edge of the structure to angle brackets on the steel plate which forms the upper edge of the base.

(f) The floating dock is then sunk, water being excluded from the interior of the coffer-dams, until the tank and coffer-dams carrying the base float free. This occurs when the draft of the base is about 28 ft.

(g) The structure now afloat is moved into position and sunk into place by filling the ballast tank with water, the base being thus deposited into its permanent location in the dry dock. It can be lifted and replaced if it does not at first sink into the correct position. No water is admitted within the coffer-dams at this period. This condition is shown in Fig. 4.

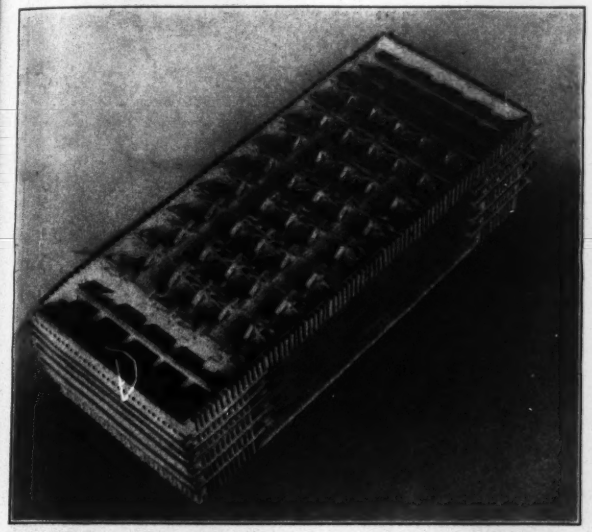


FIG. 5. BOTTOM VIEW OF MODEL OF TANK AND COFFER-DAM, SHOWING PEDESTALS

(h) The work of completing the concrete work of the dock floor and building the side walls is immediately begun and is carried to completion, except that shallow depressions are left in the floor where the pedestals rest, and also that the concrete side walls of the dry dock are carried only to a height about 1 ft. above high tide.

(i) The section is then flooded, and the upper structure detached from the base by unscrewing the nuts on the long holding-down bolts. These nuts are located on the upper edge of the structure, which is at a height of 8 ft. above mean low water.

(j) The water in the ballast tank is pumped out, and the floating structure lifted to its minimum draft. The large gates which are provided in the end coffer-dams are opened so as to clear the concrete side walls and the structure is towed clear.

(k) Upon completion of the operation of floating off the base described in (f) the construction of a new base can be immediately begun on the floating dry dock, and this new base should be ready to receive the tank and coffer-dam as soon as the operation of releasing and floating off this structure as described in (j) is completed.

This method provides the following features:

1. Practically all concrete is placed in the open air, under favorable conditions permitting inspection,

(a) By constructing the bases upon a floating dock.

(b) By holding down the bases during completion of the floor by means of a ballast tank.

(c) By utilizing steel coffer-dams to form working chambers in which the sidewalls are built.

2. Minimum risk during construction is secured by—

(a) Constructing the bases upon a floating dock.

(b) The rapid sinking of the bases by the use of a ballast tank.

(c) The additional safety in transporting and sinking the sections by the availability of the flotation of the tank, in case of leakage of the coffer-dams.

(d) The element of safety introduced by the use of well braced steel coffer-dams instead of wooden coffer-dams.

3. Rapid and economical construction is secured by—

(a) Transporting and placing the bases of flotation.

(b) The repeated use of steel coffer-dams and the handling of the coffer-dams by the flotation of the ballast tank.

(c) The practical elimination of tremie-placed concrete.

(d) The reduced building hazards.

The wall of the semicircular head of the dock is to be built of reinforced-concrete blocks, weighing about 150 tons each, molded on shore and placed by the yard floating crane. The pump well is to be a separate structure, built as a floating structure, and sunk into place adjacent to the outer-end sections of the dock.

Preliminary Repair Work on the Edison Concrete Buildings

The repair work on the reinforced-concrete buildings of the Edison plant at West Orange, N. J., seriously damaged by the fire of Dec. 9, is progressing very rapidly, especially in Building 24, which is being put into immediate service under the direction of T. L. Condron, consulting engineer. This building, which housed the phonograph cylinders, was one of those most seriously affected by the fire. In regard to this building, Mr. Condron reported to Mr. Edison as follows:

The effects of the fire have been most disastrous to the four bays at the west end, so that in my opinion it is advisable to tear down at least the three upper stories of these bays. This represents about one-seventh of the entire floor area of the building. It will probably be possible to save the first and second stories of these bays, using the third floor here as a temporary roof, rebuilding the three upper stories later. The collapse of one of the interior third story columns of this extension caused ruptures and serious strains in the surrounding panels. Where columns have been cracked diagonally across their sections they should be entirely removed and replaced.

With reference to the columns that have only been injured on the surface and for a distance of 3 or 4 in., but the centers of which are still in good condition, I recommend that they be repaired as indicated (in Fig. 4). This involves the removing of all loose concrete, leaving in place the solid center. I estimate that in the case of the 24-in. square columns, which have an original area of 567 sq.in., there will still remain at least 350 sq.in. of ground concrete.

As shown in Fig. 4, and in the views in Figs. 1, 2 and 3, these columns are being repaired by casing the remaining solid core in a circular section of concrete reinforced with vertical rods and with spirals wrapped around the old core. In effect the method is as follows: A fairly close-spaced spiral of $\frac{5}{16}$-in. rods is wrapped around the core, fitting into notches cut in vertical angles used as spacers, and additionally reinforced with eight $\frac{5}{8}$-in. round rods. This framework is shown placed in Fig. 1. It is then incased in a cylindrical steel form reaching to within about 12 in. of the bottom of the girders, and concrete is poured to form the column shown in Fig. 2. The remaining height of the column is then put in with the cement gun, giving a finished column as shown in Fig. 3.

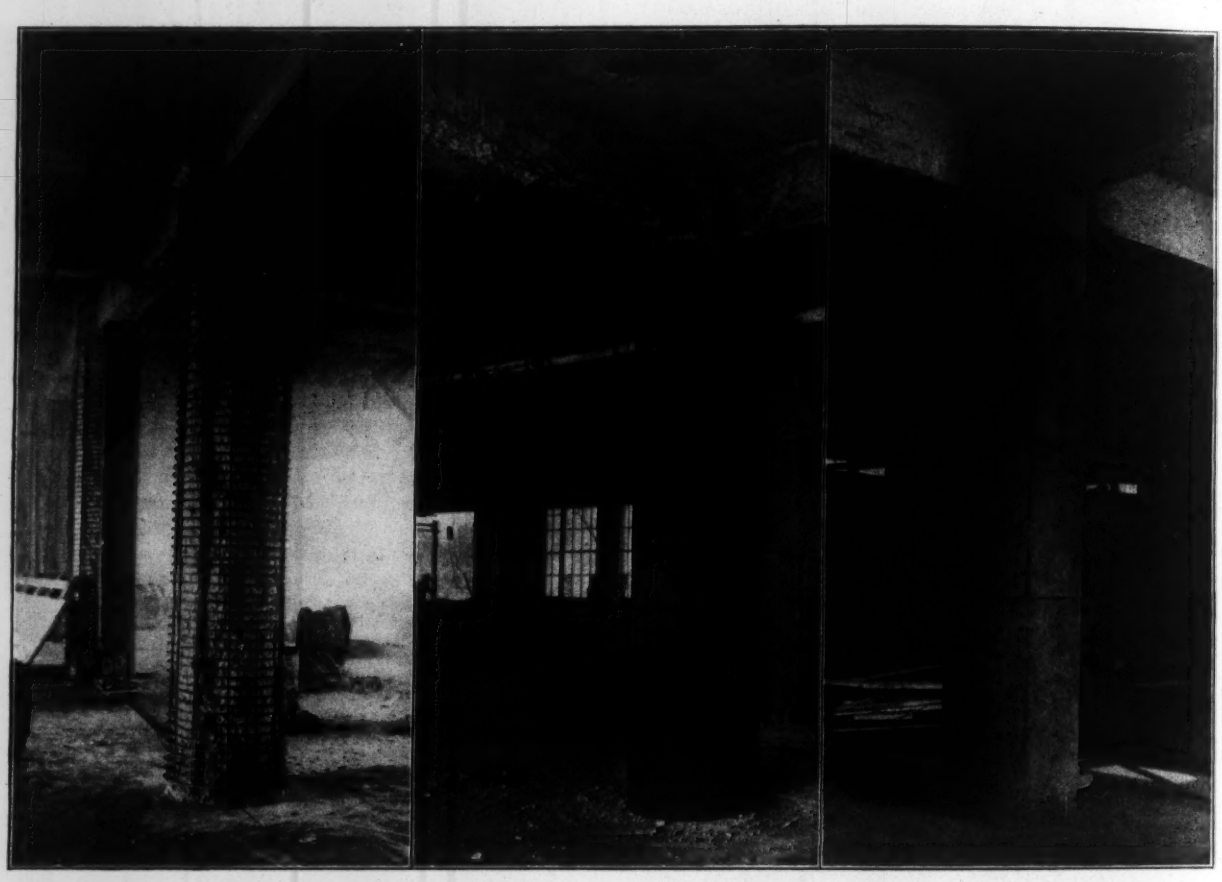
The wall columns, whose sections were very seriously affected, are being replaced by entirely new rodded and hooped columns, and those wall columns which were only partly damaged are being sledged and picked down to the solid concrete and wrapped with wire mesh, on which the concrete-mortar is plastered with the cement gun to make the finished required section.

The floor-beams and girders in this building were somewhat more seriously affected than was at first thought. In regard to these beams Mr. Condron's report to Mr. Edison reads as follows:

I am informed by the designer and builder, H. I. Moyer, that the floors were designed to carry live loads of 200 lb. per sq.ft., and that the columns and footings were proportioned accordingly. I find that in the construction of the floors, the floor slabs were not poured at the same time as the floor-beams and girders, with the result that the slabs and beams are not integral. Likewise the slabs and girders are not integral. Also the beam and girder reinforcements, instead of being bent up to near the top of the slab over at the supports, was left at least 6 in. below the top of the slab. Separation of slabs and beams were observed before the fire, and diagonal and vertical cracks had developed in these beams, although the floors were subjected to very light loading. Therefore until these floor-beams are substantially strengthened they cannot support safely the assumed floor load, because the slabs do not form the consistent compression flange as assumed in their design. The present strength of these floor-beams is indeterminate, but in my opinion where the slabs and beams are thus separated the floor loads should be limited to a uniform load not exceeding 60 lb. per sq.ft.

The slabs themselves have sufficient strength in sections to safely carry the floor loads to the beams; but the beams, which extend from column to column and from center of girder to center of girder, are the weakest feature of the floor construction.

For the repair of these beams the design shown in Fig. 5 is to be undertaken. In brief, it consists of bolting, by means of expansion bolts, two 4x4x⅜-in. angles to the underside of the floor slab and by through bolts to the beam, to attach through these angles and around the bottom of the sound concrete in the beam a continuous wire mesh reinforcement, and then to plaster with a cement gun sufficient concrete to form a square beam section. It is intended that all loose and cracked concrete be carefully removed from the beams, exposing at least the lower layer of the reinforced bars at the bottom. In some few cases both the lower and upper layers of these reinforced bars will necessarily be exposed. The sides of the beams are roughened with sandblast. It may be noted in passing that the stirrups in such beams as are exposed are not continuous U-loops, but are merely L-shaped bars descending from somewhere in or near the floor slab to the bottom of the beam, where the L-shaped bars on either side of the beam lap, as shown in Fig. 5.



FIGS. 1-3. STAGES IN REPAIR OF COLUMNS OF BUILDING 24, EDISON PLANT

The floor in Building 24 was a wooden floor on cinder fill and wooden sleepers. This was practically all destroyed by the fire, and a new floor consisting of a cement-mortar finish on the concrete of the slab is being placed. Steel sash and wire-glass have already been placed in all the usable windows, and fires are now going inside the building so as to aid the setting of the concrete in the prevailing cold weather.

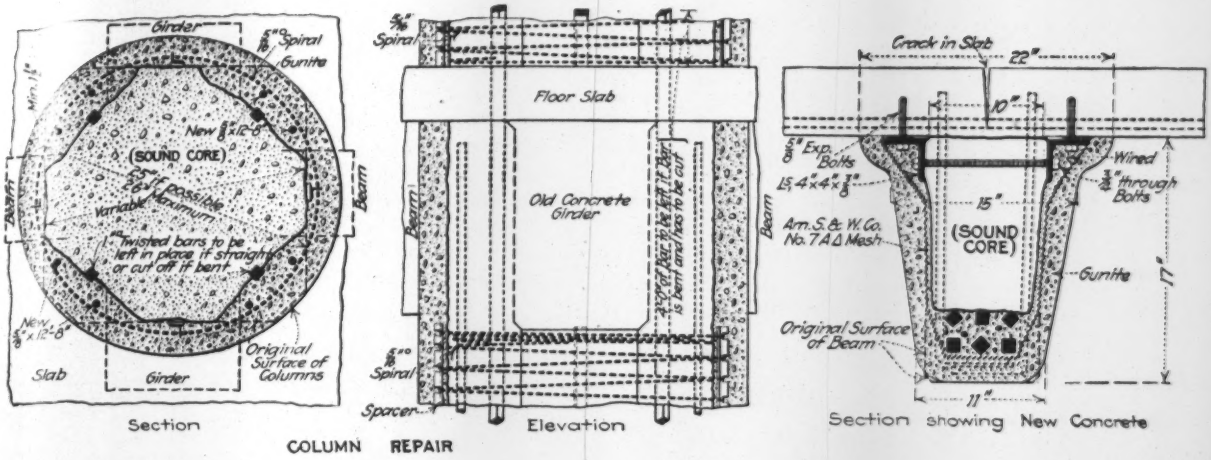


FIG. 4. REPAIR OF DAMAGED COLUMNS IN BUILDING 24, EDISON PLANT

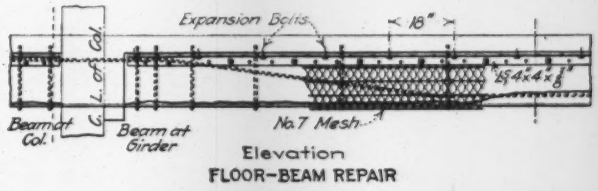


FIG. 5. REPAIR OF DAMAGED GIRDERS IN BUILDING 24, EDISON PLANT

In other parts of the plant reconstruction work is proceeding not quite so rapidly as in Building 24, which was required for immediate manufacturing purposes. In Building 11, which contained the packing-case room and in the first floor of which the columns were so seriously affected by the fire, reconstruction work shows that the destruction of the concrete of the columns was practically limited to the corners through the reinforcing rods. When the broken concrete is removed a fairly uniform circular core of sound concrete with its circumference just inside the reinforcing bars is left. It is thought that the reinforcing of these columns will be conducted in the same manner as has already been done in Building 24. That portion of Building 11 which collapsed is now being taken down by blasting and a gas torch. The office building, which was the least damaged of the reinforced-concrete buildings subjected to the fire, is now practically all in service, the new steel sash or wire-glass windows having been placed. The structure itself was very slightly damaged.

News of the Engineering World

Reported "Explosion" of a Fire Extinguisher

News accounts of the fire which destroyed the Philadelphia & Reading Ry. station at Camden, N. J., opposite Philadelphia, on Jan. 3, 1915, reported that a hand fire-extinguisher exploded. These extinguishers, which obtain their nozzle pressure by generating a high gas pressure when inverted, are such important first-aid fire appliances as to make the reported failure a matter of general interest. The following statement by the inspector of the National Board of Fire Underwriters disposes of the explosion report:

The railroad company's special officer procured the extinguisher, which was one of about six in the building, in the baggage room. Upon arriving at the scene of the fire he turned the extinguisher upside down and knocked its head against the floor to "start" it. As the extinguisher failed to operate, he raised it about two feet from the floor and brought it down with such force that he broke the cap and was immediately enveloped in its charge. He was at once taken to the hospital, and this accounts for the meager knowledge he has of the fire.

The knocking off or breaking of the cap explains the "explosion" feature. The extinguisher was of the ordinary 2½-gal. type and had been recharged by the company about four to six weeks before the fire. It is understood that all extinguishers in the company's building were well cared for and regularly charged.

The fire gained considerable headway before the arrival of the special officer on the scene, and he says it was of such proportions that even had no difficulty been experienced with the extinguisher it would have been of no avail. For that reason the so called explosion is not of serious importance.

A Federal Court of Appeals Decision on Flat Slab Patents

On Dec. 10, 1914, the United States Circuit Court of Appeals, Eighth Circuit, handed down a decision in favor of John L. Drum against C. A. P. Turner, reversing a decision of the lower court which dismissed a complaint of the infringement of patent No. 698,542 issued Apr. 29, 1902, to O. W. Norcross for a metallic and concrete flooring, by a flooring made substantially in the manner described in patents No. 985,119 and No. 1,003,384 issued to C. A. P. Turner Feb. 21, 1911, and Sept. 12, 1911, respectively. Sitting in the Court of Appeals

were Justice Sanborn, circuit judge, and Justices Trieber and Reed, district judges.

Justice Sanborn delivered the opinion of the court, which was in substance that claims 2, 3 and 4 of patent No. 698,542 are valid and are infringed by flooring constructed in the way described in patents No. 985,342 and No. 1,003,384; that the decree below must be reversed and that the case must be remanded to the court below with instructions to render a decree in favor of the plaintive (Mr. Drum) for an accounting and an injunction. Justice Sanborn's main conclusions are that with the exception of one claim which was a general one and covered by a previous patent issued to one Seeley, the Norcross patent is a broad basic patent covering "a monolithic flooring composed of a metallic network imbedded in concrete which would sustain itself and its load upon separated posts without the use of girders, floor-beams, or other horizontal supports."

The appellee, C. A. P. Turner, is to appeal for a reopening of the case on newly discovered evidence. The suit in the New Jersey circuit of the Federal Court of Appeals on Turner patent No. 1,003,384 is soon to be ready for argument, testimony having been taken continuously for some years past.

*

A Bridge Sidewalk Failure Due to Paving Expansion

A remarkable progressive failure of the reinforced-concrete sidewalk cantilever of the Dallas-Oak Cliff viaduct at Dallas, Tex., on or about Dec. 26, 1914, was due to the pressure on the curb of the expanding wood-block pavement. This viaduct, one of the longest concrete-

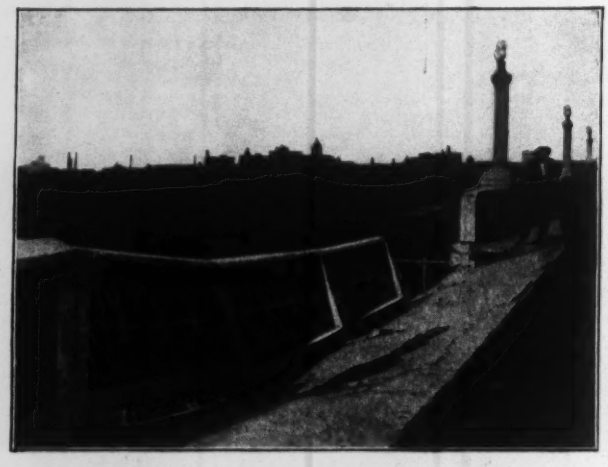


FIG. 1. WRECKED SIDEWALK, DALLAS-OAK CLIFF VIADUCT

arch bridges in the world, comprises 51 arches, and 620 ft. of trestle, with a central 90-ft. plate-girder span and has a total length of 5106 ft. It was described in detail in ENGINEERING NEWS, Mar. 30, 1911, p. 392. From that article the accompanying Fig. 2, showing the sidewalk detail, has been taken.

Originally, the viaduct was paved with an asphaltic macadam, which failed to stand up well under the very heavy traffic, so that during the past summer the roadway was repaved with 4x4x8-in. creosoted long-leaf yellow-pine blocks set in a bed of cement-mortar and with joints filled with hot asphalt. At either curb line there was a 1-in. expansion joint filled with asphalt. In the construction of the bridge the shoulder (Fig. 2) at the gutter was not poured integral with the floor slab, but was poured on the top of the slab, so that there was a separation plane between the curb, floor slab and shoulder. No street-car tracks had been laid.

The month of December in Dallas was very rainy and was followed about Christmas time with freezing weather. The first marked failure was noted on Dec. 26; this fail-

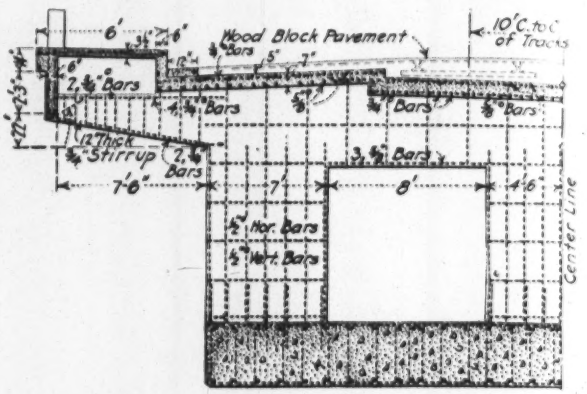


FIG. 2. TYPICAL SECTION THROUGH DALLAS-OAK CLIFF VIADUCT, SHOWING SIDEWALK DETAIL

ure is shown in Fig. 1. About 45 ft. of the sidewalk on the west side of the viaduct collapsed as shown, the expansion of the wood-block pavement pushing the gutter shoulder, curb and sidewalk slab out, twisting the fascia girder, and breaking the cantilever beams approximately on a vertical plane with the inside of the fascia girder. The failure occurred between the expansion joints over one of the arches about midway between an abutment and the central girder span.

According to N. Werenskiold, civil engineer, of Dallas, who has forwarded some information on the failure, the concrete appears to be of good quality. The fractures took place as follows: A horizontal failure by sliding between first pouring of floor slab and the gutter shoulder and curb; a vertical failure by rupture on sidewalk slab near curb; a rupture on account of poor bond and separate pouring between the top of the floor-beam and bottom of slab; a vertical break at end of cantilever beam, flush with the inside of fascia girder. The fascia girder dropped to the ground, and outside of the sidewalk slab dropped to the remaining part of the cantilever beam.

The County Engineer states that most of the filling in the expansion joints was forced out, and estimates that the expansion of the wood blocks in the 41 ft. amounted to approximately 8 in. The surface of the wood block is nearly a parabola, with short tangents on each side, having a crown of 8¼ in. in the 44-ft. span, Mr. Werenskiold estimates that the lateral pressure that would have caused buckling of the pavement is approximately 6000 lb. per lin.ft. of curb. A shearing stress of about 21 lb. per sq.in. on the 24 in. under the gutter shoulder and curb would have resisted this. The strength should have been many times this with due precautions in the current construction of the concrete work. The pavement seems to conform with good modern practice and to be of

a very good quality and the County Engineer appears to have taken every reasonable precaution to insure good inspection and good work.

The location shown in Fig. 2 is the only one where actual failure has occurred, but there are at least a dozen more arches in the pavement at various parts of the viaduct, over which the curb between expansion joints has been pushed out from ¼ to 1½ in., and several cracks have appeared at the ends of the cantilever beams. It is estimated that the damage amounts to about $2500.

Wholesale Reduction of New York State Engineer's Staff

Announcement was made Jan. 8, that over 400 positions in the New York State Engineer Department were abolished, with an incidental reduction in the state's expenses of about $2000 a day. The positions abolished include 2 terminal engineers at $4000 per annum; 3 supervising engineers at $5000; 12 resident engineers at $3000; 77 assistant engineers at $5 to $7 per diem; 12 bridge engineers at $125 to $150 per month; 18 levelers at $4 to $5 per diem and 15 masonry inspectors at $4 and $5 per diem.

Governor Whitman is quoted by the New York *Times* as follows:

> As a result of this investigation the State Engineer has determined to consolidate the departments of Barge Canal and Terminals, abolishing the positions of Division Engineers of Terminals and throw the work now handled by such engineers under the direction of the three Division Engineers of the Barge Canal.
>
> By the reduction in the force, the State Engineer figures that he will effect a saving of approximately $1350 per day in the engineering salaries now paid in the department. In addition there will be a considerable saving in the item of office rents and maintenance.

Developments in the State Highway Department are promised soon.

Severe Cable Burnout in the Subway, New York City

In the worst accident in the history of the New York Rapid Transit subway on Jan. 6 one person was asphyxiated, about two hundred others were overcome by smoke and gases from burning insulation and metal, and the entire subway system was tied up for the better part of a day. During the morning rush hour, a short-circuit, caused by defective insulation or a heavy overload, resulted in the burning out of about thirty 11,000-volt, alternating-current and twenty 550-volt direct-current feeders, which passed through a manhole near 53d St. The tie-up of traffic affected four boroughs: Manhattan, Brooklyn, the Bronx (for a half-hour because of congestion of trains), and Queens (New York & Queens street railway).

High-tension current is supplied to the subway by the 59th St. generating station. The 11,000-volt feeders are laid under 59th St. to Broadway, where they turn north and south. The accident occurred in a splicing chamber at 53rd St. and Broadway at 8:01 a.m. and the system south of 59th St. was out of commission until 4 p.m.

The manholes and ducts which carry the high- and low-tension subway feeders are a part of the subway structure but, with the exception of ventilating openings at top and bottom of the manholes, are shut off from the body of the tunnel. A rolling steel door gives access from the subway to the splicing chamber for inspection and repair. It was through these ventilating openings and the fire-damaged metal door that the smoke and fumes escaped into the tunnel. The high-tension cables were 167,000 circ.mils in cross-section; the direct-current 2,000,000 circ.mils.

The Public Service Commission for the First District has called upon its engineering force to report upon a plan for separating the splicing chambers from the subway; also recommendations for the enlargement, rearrangement, or increase, of the passenger emergency exits, and for the complete separation of lighting and signaling circuits from the power cables; for an independent circuit to furnish current for the ventilating fans; and for the illumination of signs at emergency exits. All the wood cars in the subway will be replaced by cars of steel construction. There are over 400 wood cars there at the present time.

The Engineering Foundation

"The Engineering Foundation" is the name which has been chosen for an endowment fund just established by the United Engineering Society, which is to be "devoted to the advancement of the engineering arts and sciences in all their branches, to the greatest good of the engineering profession and to the benefit of mankind."

This fund will be administered by the Engineering Foundation Board, which will be elected by the Trustees of the United Engineering Society, which is the corporation that holds the Engineering Societies Building in trust for the National Societies of Mechanical, Mining and Electrical Engineers.

The Engineering Foundation Board will be made up of 11 members, as follows:

> The President of the United Engineering Society, ex-officio.
>
> Three Trustees of the United Engineering Society, one each from the American Institute of Mining Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers.
>
> Three members, nominated one each by the governing bodies of the above societies.
>
> Two members, nominated by the governing body of the American Society of Civil Engineers.
>
> Two members at large, to be selected by the Trustees of the United Engineering Society.

The initial gift for the endowment of the Engineering Foundation fund is from a noted engineer, whose name will be announced at the meeting to be held for the inauguration of the Foundation, on Jan. 27, at 8:30 p.m., in the auditorium of the Engineering Societies Building.

The meeting will be open to all members of the engineering profession and their ladies. Addresses will be made by Gano Dunn, President of the United Engineering Society, Dr. Henry S. Pritchett, President of the Foundation for the Advancement of Teaching, Dr. Robert W. Hunt, Past-President of both the Mining and Mechanical Engineers, and Dr. Alexander J. Humphreys.

Water-Supply Improvements for Ottawa, Ont., were involved in the municipal election held on Jan. 4. It is reported that three members of the five members of the Board of Control elected on that occasion, including the mayor-elect, are in favor of the water-supply project outlined on p. 43 of our issue of Jan. 7, 1915; that a fourth member is neutral on the proposition, and that only one, an ex-mayor under whose administration the Binnie and Houston project was launched, is against the new scheme. The people did not vote directly on any improvement in the source of supply, but they did authorize the issue of $425,000 of bonds for reinforcing the

water-distribution system in accordance with what is known as the Lea plan. The adoption of the proposition for the new temporary water-supply, outlined in our issue of Jan. 7, would reduce the cost of this water-distribution reinforcement plan to $365,000, making the entire estimated cost for the new water-supply proposition and the reinforcement of the distribution system $790,000.

The Bursting of a Water Main in Columbus, Ohio, at 1:30 a.m. on Jan. 4 stopped the water-supply of practically the entire city. The pumps at the water-works were shut down while the leak was repaired.

The Short Course in Highway Engineering planned by the University of Illinois for Jan. 11 to 22, 1915, has been abandoned according to an official announcement "to prevent the possible spread of foot-and-mouth disease, and at the urgent request of the State Highway Commission upon the advice of the State Veterinarian, because of the recent new cases of infection of that disease."

Passenger Travel on the best managed American railway lines is as safe as anywhere in the world. This has been repeatedly shown by published statistics of accidents to passengers on leading American railway systems. On the entire Pennsylvania Railroad system, with 26,198 miles of railway track, not a single passenger was killed in a train accident in 1914. During the year 188,411,876 passengers were carried on the entire system, and the aggregate distance traveled by passenger trains was 67,389,381 miles. More than 3000 trains were run every day and more than a million trains during the year.

A System of Electric-Light Block Signals to replace the ordinary semaphores has been developed by the signal engineers of the Pennsylvania R.R. and is shortly to be installed on 16 miles of four-track road extending westward from Philadelphia as soon as this section is equipped for electric traction, according to a statement of Mr. A. H. Rudd, Signal Engineer, in the "Railway Age Gazette." The signals are given by fixed electric lamps mounted on a pole and so controlled that the position of the lamps which are burning will gave the same indication that the position of a semaphore arm does. The lamps used are 12-volt, 4-cp., 5-watt tungsten lamps, having a concentrated filament and with the light directed by heavy 5¾-in. lenses. Notwithstanding the small candlepower of these lamps, their light is so concentrated by the lenses that it is claimed they can be readily seen in bright sunlight at 4000 ft. distance. In fact, so powerful is the light that the potential is cut down to three volts at night. All the lamps are of the same color, hence color indications are done away with and signals are given by position by night as well as by day. The only moving parts of the signal are the control relays which are necessary with any system. The risk of a semaphore arm freezing or sticking in the clear position when it should indicate danger is done away with. From the records of the Pennsylvania R.R., it appears that this should reduce signal failures by at least 40%. The current for lighting the signal lamps will be taken from the power line, so that the cost will be small. It is also claimed that the cost of installation and maintenance will be less than with the ordinary semaphore system.

PERSONALS

Mr. William R. Patterson has resigned as Assistant Commissioner of Public Works of the Borough of Manhattan, New York City.

Mr. George W. Lamson has resigned his position with the Union Oil Co., of California, to represent the Standard Oil Co. (New Jersey) at Chicago. His address is 1451 Railway Exchange.

Mr. S. B. Robbins, M. Am. Soc. C. E., has opened an office in the new Ford Building, Great Falls, Mont., as Consulting Engineer, specializing in irrigation, drainage, and agricultural development.

Mr. Paul L. Bean, Associate Professor of Civil Engineering at the University of Maine, has been appointed Chief Engineer of the Maine State Public Service Commission, at a salary of $2500 per annum.

Mr. M. A. Giff, recently connected with the Union Oil Co. of California, is now associated with Mr. George W. Lamson, 1451 Railway Exchange, Chicago, Ill., representative of the Standard Oil Co. (New Jersey).

Mr. Grant Hall, General Manager of the western lines of the Canadian Pacific Ry., has been made Vice-President and General Manager of the company's lines west of Port Arthur, with headquarters at Winnipeg, Man.

Mr. C. P. Howard, M. Am. Soc. C. E., of Chicago, formerly a member of the firm of Berry, Howard & Roberts, has opened an office as Consulting Engineer, specializing in railway work. His office is at 1703 Transportation Building, Chicago.

Mr. Arba B. Marvin, a graduate in engineering, class of 1900, of University of Wisconsin, a patent attorney, of New York City, has become a member of the firm of Rennie, Davis & Marvin, Patent Attorneys, 35 Nassau St., New York City.

Brig.-Gen. Theodore A. Bingham, Corps of Engineers, U. S. A., retired, former Police Commissioner of New York City, and for the past few years Consulting Engineer of the New York City Department of Bridges, will leave the city service Feb. 1, due to the abolition of his office.

Mr. Benjamin G. Fernald, Assoc. M. Am. Inst. E. E., has been made District Manager of the Kerr Turbine Co., Wellsville, N. Y., in charge of the company's New York City office. Mr. Lawrence G. Hanmer will continue to be associated with the New York office.

Mr. G. W. Rice, Assoc. M. Am. Soc. C. E., who has been Chief Engineer of the Goose Lake Valley Irrigation Co. for the past seven years on the construction of the Goose Lake Valley Irrigation project near Lakeview, Ore., has resigned, effective about Feb. 1.

Messrs. Sayler and Seddon, 606 Gumbel Building, Kansas City, Mo., have dissolved partnership. The business will be continued at the same address by Wm. H. Saylor. The firm has been in business for nine years. Mr. Seddon's plans are as yet unannounced.

Mr. Edgar A. Cline, formerly Consulting Engineer, with offices at 713 Scarritt Building, Kansas City, Mo., has accepted the position of Superintendent in charge of the ventilating department of the Henry Weis Cornice Co., of Kansas City, Mo. This department has been organized within the last year.

Mr. E. J. Ladd, who has been connected with the contracting department of the Chicago Bridge & Iron Works, Chicago, Ill., for more than 20 years, is now in charge of a new office which the company has opened at Monticello, Fla., and will have charge of the company's interests in Georgia, Florida and Alabama.

Messrs. Virgil G. Marani, M. Am. Soc. C. E., former Building Inspector of the City of Cleveland, Ohio, and J. E. A. Moore, M. Am. Soc. C. E., recently Chief Engineer of the C. O. Bartlett & Snow Co., also of Cleveland, have formed the firm of Marani & Moore, Consulting Engineers, with office at 1900 Euclid Building, Cleveland.

Mr. Fred L. Mulcahy, who has been employed as Engineer for the Metropolitan Park System of the State of Rhode Island, has been engaged by Mayor Kane, of Lawrence, Mass., to take charge of the construction of the Central Bridge, Lawrence, for the city. Mr. Mulcahy is a native of Lawrence and is an engineering graduate of Brown University.

Mr. P. E. Crowley, recently General Manager of the New York Central & Hudson River R.R., has been appointed Assistant Vice-President of the Operating Department, with office at New York. Mr. Crowley began railway work as a messenger boy with the Erie R.R. in 1878. In 1890 he entered the service of the New York Central & Hudson River R.R.

Mr. R. L. Fitzgerald, Electrical Engineer formerly in the employ of the Gary (Ind.) Light, Heat & Water Co., has been appointed Business Manager of Winnetka, Ill., a residental suburb of Chicago. He will have full charge of municipal affairs under the supervision of a local board of trustees. Mr. Fitzgerald is an engineering graduate of Purdue University.

Mr. Leon S. Moissieff, M. Am. Soc. C. E., will retire as Chief of the Division of Design, New York City Department of Bridges, Feb. 1, due to a permanent reduction in the Bridge Department staff. It is reported to be the ultimate plan to abolish the Department of Bridges and establish a Department of Highways which will include the maintenance forces of the present Bridge Department and the Bureau of Highways.

Mr. Claude E. Chappell, Assoc. M. Am. Soc. C. E., present City Manager of Big Rapids, Mich., has been appointed City Manager of Jackson, Mich. Mr. Chappell is a graduate in civil engineering of the University of Michigan, and has had a varied experience in engineering construction work. He was formerly with Mr. Dabney H. Maury, M. Am. Soc. C. E., Consulting Engineer, of Chicago, and was appointed City Manager of Big Rapids about a year ago.

Mr. Harry G. D. Nutting, formerly an engineer for the Wisconsin Railroad Commission, and recently Assistant to the President of the Wisconsin Public Service Co., Wisconsin Ry., Light & Power Co., and the Evanston (Ill.) Ry. Co., has been appointed Manager of the Engineering Department of the John E. De Wolf Co., Investment Bankers, Railway Exchange Building, Milwaukee, Wis. Mr. Nutting will assist the buying

department in the investigation of public-utility issues, and will have general charge of the public-utility properties controlled by the company. He will also continue his private practice as Consulting Engineer on public-utility problems, at the above address.

Mr. George P. Du Bose has been made Superintendent of the Holt Manufacturing Co., Stockton, Calif. After the San Francisco fire Mr. Du Bose took an active part in the rebuilding of the city, acting as Superintendent of Construction for D. H. Burnham & Co. and the Thompson-Starrett Co. As General Superintendent of Bridge Construction for the Western Pacific Ry., he built most of the bridges in Nevada and upper California. He was also Consulting Engineer in the construction of the Chilkoot and Spring Garden tunnels in Feather River Cañon. More recently he has had charge of irrigation construction work for the Solano Irrigated Farms.

Mr. Abraham T. Hardin, Assoc. M. Am. Soc. C. E., has been appointed Vice-President of the New York Central R.R., in charge of the Operating Department, which embraces transportation, construction, roadway and equipment. His headquarters will be at New York. Mr. Hardin is a graduate in civil engineering of the University of South Carolina. He started his career as a telegraph operator on the Richmond & Danville R.R., becoming an agent and stenographer on that road, which position he held for eight years. He then went to college, and after graduation spent four years in the employ of the Southern Ry. In 1898 he was made Supervisor and Division Engineer of the Eastern Division of the New York Central & Hudson River R.R., and by a rapid promotion has reached the position he now occupies.

Mr. Henry Welles Durham, M. Am. Soc. C. E., who has been Chief Engineer of Highways of the Borough of Manhattan, New York City, since 1913, will leave this position on Feb. 1. Borough President Marks has appointed in Mr. Durham's place Mr. Eugene W. Stern, M. Am. Soc. C. E., of New York City, Secretary of the Institute of Consulting Engineers. During the three years in which Mr. Durham has been in charge of the Bureau of Highways, he has been responsible for extensive repaving work, involving an expenditure of over $7,000,000, and the resurfacing of over 25% of the total area of streets in Manhattan, including many of the heaviest traffic thoroughfares. Mr. Durham was a member of the first party of engineers who went down to Panama when the United States assumed control there at the beginning of work in 1904, and for three years following was Resident Engineer under the Isthmian Canal Commission, in charge of design and construction of the water-works, sewers and highways of the City of Panama and vicinity. In 1907 Mr. Durham was appointed Resident Engineer of the Cape Cod Canal construction under William Barclay Parsons. He left that position in 1912, when he was placed by Borough President McAneny in charge of the Manhattan Bureau of Highways. During 1913 he spent several months in the study of European practice in street paving. The City of New York has just printed his complete report based on the results of these studies. A summary of his investigations was published in "Engineering News" of July 2, 1914.

OBITUARY

Thomas Coltrin Keefer, Honorary Member of both the American and Canadian Societies of Civil Engineers, one of the oldest and most distinguished of American civil engineers, died at his home in Ottawa, Ont., Jan. 7, in the 94th year of his age. He was born in Thorold, Ont., and began his professional career in 1836 on the reconstruction of the Erie Canal, in New York. Soon after he went to the Welland Canal, where he became Division Engineer, continuing in this work until 1845, when he resigned to become Chief Engineer of the Ottawa River works, which he completed in 1848. The following year he wrote his "Philosophy of Railways" and also gained the Lord Elgin prize for the best essay on "The Influence of the Canals of Canada on her Agriculture." This last named work earned for the author the right to be considered the father of railways in Canada; in it he argued that as the sparse population of the country would hardly admit the construction of railways as a commercial speculation, it was the duty of the government and the municipalities to aid this construction in every manner possible.

In 1850 Mr. Keefer was engaged upon the survey for the improvement of navigation in the St. Lawrence River above Montreal, and upon the connection of this river with the St. John, either by rail or canal. He was later employed by the Canadian government to act with an appointee from the United States to report upon the Canadian trade with this country. The report was made, and a second report in 1852, which led to the Reciprocity Treaty of 1854. In 1851 Mr. Keefer made the preliminary surveys for the Grand Trunk Ry., and for bridging the St. Lawrence at Montreal for railway communication with the United States. He was one of the Canadian commissioners to the London International Exhibition in 1851, and when in England for that purpose he advocated before Parliament the abandonment of the then Canadian railway gage for the prevailing standard gage in New York and New England. In 1853 he was made Engineer of the Montreal Harbor Commission. Subsequently he had charge of the construction of the water-works at Montreal, Halifax, Ottawa, and other Canadian cities. He was also Chief Engineer of railways in upper and lower Canada, and was Commissioner for Canada to the London Exposition of 1862, and was Executive Commissioner to the Paris Exposition in 1878, being decorated as an officer of the Legion of Honor for services in connection with the duties of a member of the International Jury on Architecture and Engineering.

Mr. Keefer was very prominently identified with construction and progress of the Canadian Pacific Ry., and in the years 1869 to 1870 published a series of letters strongly advocating its construction as a step made necessary by the extinguishment of the claims of the Hudson Bay Co. to the Great Northwest Territory, as essential to Canadian federation and internal development. Following 1886 Mr. Keefer was Chairman of the Commission on Floods of the St. Lawrence River. He was one of the charter members of the Canadian Society of Civil Engineers, a member of the American Society of Civil Engineers since 1877, and an honorary member of the Institution of Civil Engineers of Great Britain. A portrait and more complete biography, of which the foregoing is an abstract, was published in "Engineering News," Jan. 21, 1888.

ENGINEERING SOCIETIES

COMING MEETINGS

AMERICAN SOCIETY OF ENGINEERING CONTRACTORS.
Jan. 15. Annual meeting at New York City. Secy., J. R. Wemlinger, 11 Broadway, New York City.

AMERICAN WOOD PRESERVERS' ASSOCIATION.
Jan. 19-21. Convention at Chicago, Ill. Secy., F. J. Angier, Mt. Royal Station, B. & O. R.R., Baltimore, Md.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 20-21. Annual meeting in New York. Secy., Charles Warren Hunt, 220 W. 57th St., New York City.

AMERICAN SOCIETY OF HEATING & VENTILATING ENGINEERS.
Jan. 20-22. Annual meeting at New York City. Secy., J. J. Blackmore, 29 W. 39th St., New York City.

OHIO ENGINEERING SOCIETY.
Jan. 20-22. Annual meeting at Columbus, Ohio. Secy., John Laylin, Columbus.

INDIANA ENGINEERING SOCIETY.
Jan. 21-23. Annual meeting at Indianapolis. Secy., Charles Brossmann, 1616 Merchants Bank Building, Indianapolis, Ind.

THE ENGINERING FOUNDATION.
Jan. 27. Inauguration meeting in Engineering Societies building, New York City.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
January 27-29. Annual meeting at Springfield, Ill. Secy., E. E. R. Tratman, 1144 Monadnock Block, Chicago.

AMERICAN CONCRETE INSTITUTE.
Feb. 9-12. Convention at Chicago, Ill. Secy., E. E. Krauss, Harrison Bldg., Philadelphia, Penn.

CHICAGO CEMENT SHOW.
Feb. 10-17. At Chicago. Secy., J. P. Peck, Universal Portland Cement Co., Chicago.

AMERICAN CONCRETE PIPE ASSOCIATION.
Feb. 15-16. Annual convention at Chicago. Secy., E. S. Hanson, 538 South Clark St., Chicago, Ill.

IOWA ENGINEERING SOCIETY
Feb. 17-19. Annual meeting; at Iowa City. Secy., S. M. Woodward, Iowa City, Iowa.

Arkansas Engineering Society—The fourth annual meeting will be held at Little Rock, Ark., Jan. 18-19. The Secretary is W. J. Parkes, Pine Bluff.

Colorado Good Roads Association—The fifth annual convention will be held in Denver, Jan. 20-21. The State Association of County Commissioners will meet in the same city, Jan. 18-19.

Engineers' Club of St. Louis—The new officers of the Club are as follows: President, John W. Woermann; First Vice-President, W. E. Rolfe; Second Vice-President, H. I. Finch; Secretary, S. W. Bowen; Treasurer, F. T. Cutts.

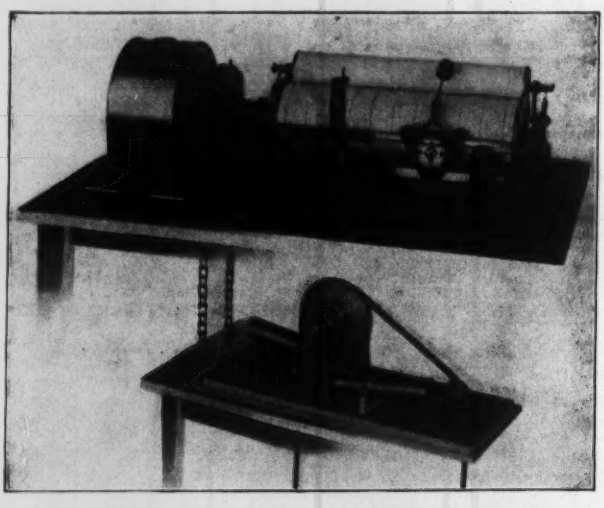
American Society of Engineering Contractors—The annual meeting will be held in New York City on Jan. 15. In the evening the annual banquet and entertainment will be held at Bustanoby's. The Secretary is J. R. Wemlinger, 13 Broadway, New York City.

Canadian Society of Civil Engineers—The following have been nominated for the various offices of the Canadian Society of Civil Engineers: President, F. C. Gamble, Chief Engineer, Public Works Department, Victoria, B. C.; Vice-President for three years, A. E. Doucet, District Engineer, National Transcontinental Ry., Quebec; A. St. Laurent, Public Works Department, Ottawa. Vice-President for one year, E. E. Brydone-Jack, professor of Civil Engineering, Manitoba University; Gordon Grant, Chief Engineer, National Transcontinental Ry., Ottawa.

Appliances and Materials

Stevens Distant Water-Stage Recorder

The utility of the Stevens water-stage recorder, described in "Engineering News," July 25, 1912, has been increased by a long-distance reporting attachment (shown in the accompanying view). The "sender" has a spine pulley over which runs a perforated bronze band connecting a float and counterpoise. On the same shaft are two ratchet wheels, with opposed teeth, operating spring hammers; a blow is delivered once for each stage interval (as 0.05 ft. height, for example). One hammer is for rising stage and one for falling. When a hammer is released it strikes the end of a pivoted inclined tube. A metal ball within is driven forward by the impact, causing the tube to dip and to hold an electric circuit closed until the ball rolls back (interval arranged to be about 1 sec. to insure operation of recorder).



STEVENS LONG-DISTANCE WATER-STAGE RECORDER

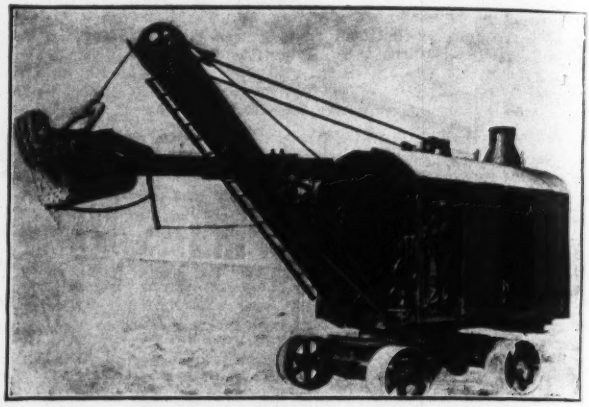
The receiver is fixed to the bedplate of a recorder; in place of the float pulley on the shaft of the spine wheel that drives the pencil carriage, there are fixed two ratchet wheels with opposed teeth. Playing over these ratchets are pawls carried by loose arms on the spine-wheel shaft. One or the other of the arms is pulled down by a solenoid whenever the proper circuit is closed by the sender. The ratchet wheels are moved each time a distance proportional to one-stage interval and the pencil carriage moved to the right or left to record the change in water level. The simple machine requires two circuits and three wires, unless a good ground connection is secured. Only intermittent current is required and ordinary dry cells serve. Any length of circuit may be used over which a telegraph relay can be operated. The system is also adapted to duplex and differential stage recorders where two distant levels or their difference is to be recorded. The apparatus was designed and patented by J. F. Stevens, Consulting Engineer, Portland, Ore., and is made by Leupold, Voelpel & Co., of Portland.

* * *

Small "Single-Line" Steam Shovel

A single-line revolving steam shovel, equipped with a ⅝-cu.yd. dipper was recently placed on the market. The following information about it has been furnished by J. G. Rauch, of the American Steel Dredge Co., Fort Wayne, Ind., the makers.

Ordinarily the hoisting cable is reeved over three sheaves between dipper and boom point; with the single line there is no tackle so exposed. For the same boom position there is somewhat more horizontal pull on the dipper, due to the large single sheave. Elimination of tackle increases reach and lift some 2 ft. Only about one-third the amount of cable is wound up as with a three-part line, which gives a smaller drum and more cab room. The engine size is not unusual, but speed is reduced by compound gearing to the drum. Independent swinging engines are placed at the side of the hoisting engines, leaving the space between the latter and the boiler



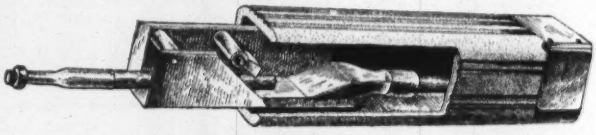
A ONE-MAN STEAM SHOVEL

unobstructed. The dipper, attached to a 16½-ft. boom by a structural-steel handle, can dig 2 ft. below the wheel level. The working weight of the entire machine is 35,000 lb. Only one operator is required.

The nearest prior approach to a single-line shovel was a railway machine built for the Atlantic Equipment Co. and described in "Engineering News," Aug. 4, 1904. In place of one heavy line, there was a smaller cable doubled; both ends were fastened to the drum, the boom-point sheave was double grooved, and there was an equalizing thimble sheave at the dipper. The hoist engines were mounted on the boom.

* * *

An Improved Scheme for Recovering Broken Conduit Rods—The pickup device shown in the accompanying illustration has recently been designed for recovering broken rods and lost tools in underground conduits more easily than possible with any fishing scheme or by tearing up conduit. A box loosely fits the interior of a duct and carries two flaps or



A PICKUP TOOL FOR CONDUIT WORK

doors. It is pushed ahead by a handle to which the ordinary jointed conduit rods may be attached. When the lost tool or broken rod is met, the sharp front edges of the box guide it inside; after it has passed the flaps, a backward pull on the pickup causes these to grip so that the obstruction can be pulled out with the pickup. This device was invented by M. Blumenthal and is made by B. S. Barnard & Co., 50 Church St., New York.

* * *

Grade-Crossing Warnings

A flashing signal to warn automobilists of dangerous curves and railway crossings at night is being tried out by the City of Philadelphia at Wynnewood Ave. and City line, Overbrook. This device, called the "Highway Beacon," is a production of the American Gas Accumulator Co., of Philadelphia, and experiments are reported under way in London and at Potomac Park, Washington, D. C. The new lamp has a lens, 5 in. in diameter, a flasher and a gas-pressure regulator. It is mounted on a 10-ft. wood post, at the base of which in an acetylene-gas tank with storage capacity for 50 cu.ft. The beacon flashes 60 times per minute, and the gas costs about 40c. per month, the tank not requiring renewal for two months. This flasher is, of course, of the same general design as that used in railway signaling. The latter type has been fully described in "Engineering News," Apr. 9, 1914, p. 776.